United States
Environmental Protection
Agency

Office of
Research and Development
Cincinnati, OH

September 1991
AWBERC-91-09

EPA

Always a River

Supplemental Environmental Education Curriculum on the Ohio River and Water Grades K - 12

Notice

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U.S. Environmental Protection Agency 1991

Acknowledgments

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The development of this curriculum was sponsored by the U.S. Environmental Protection Agency (EPA), Office of the Senior Official for Research and Development, Center for Environmental Learning, Cincinnati, Ohio. Thelma Johnson and Ann Gunkel of the Center for Environmental Learning provided management and overall direction for the project, and Jennie Doddy provided clerical assistance. Susan Richmond, Linda Saunders, Heidi Schultz, Pat Kottmann, Anne Donovan, and Erika Haas of Eastern Research Group, Inc. (ERG), Arlington, Massachusetts, provided writing and editorial support. Stephen Wilson of the EPA Center for Environmental Research Information and Steven Waltrip of the Risk Reduction Engineering Laboratory developed the graphics, and Karen Ellzey, David Cheda, and Aarre Laakso of ERG designed and desktop published the document.

Preface

This curriculum was developed as a significant component of the project, *Always a River: The Ohio River and the American Experience*, a six-state collaboration devoted to exploring the historical and cultural development of the Ohio River. The *Always a River* project is being jointly sponsored by the Humanities Councils of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia, and the National Endowment for the Humanities. Its primary purpose is to provide people living in the states through which the Ohio River flows with an opportunity to explore their local cultural and natural history. One feature of the *Always a River* project is a specially outfitted barge carrying an interactive exhibit that, during the summer of 1991, stopped at various locations along the entire length of the Ohio River, from Pittsburgh, Pennsylvania, to Cairo, Illinois. The exhibits from this "floating museum" became a permanent part of the Clarksville, Indiana, Interpretive Center upon completion of the barge's journey. Other features of the project include book readings and discussion programs in local libraries, a public history conference, a series of educational programs, and the preparation of this curriculum for students in grades kindergarten through twelve.

As its contribution to the *Always a River* project, the U.S. Environmental Protection Agency (EPA), Office of the Senior Official for Research and Development, Center for Environmental Learning, developed this curriculum through a collaborative effort, with the assistance of many individuals and organizations. The result, *Always a River: Supplemental Environmental Education Curriculum, Grades K-12,* focuses on the environmental aspects of water and the Ohio River. The curriculum was developed as an interdisciplinary document, offering a wide variety of activities that can be integrated into existing curricula in science, social studies, mathematics, English, art, music, and other subject areas. A series of workshops have been conducted to introduce instructors to the curriculum and to provide guidance on its use.

We at EPA believe that environmental education is critical to young people's understanding of the complex issues facing us in the world today. It is our hope that curricula such as this will provide a valuable supplement to existing educational programs.

How to Use This Guide

Always a River: Supplemental Environmental Education Curriculum on the Ohio River and Water, Grades K-12 is a series of interactive hands-on activities, supported by background information, designed to engage students of all grade levels in investigating the Ohio River and its importance to the states through which it flows. The curriculum encompasses four primary objectives:

1. To demonstrate that the Ohio River is part of a total ecosystem that includes its floodplain and watershed.
2. To introduce the biological, physical, and chemical aspects of water and their importance to living things.
3. To explore human use of the Ohio River and the environmental impacts of human activity on the river and its watershed.
4. To examine the Ohio River's influence on historical cultures and its implications for shaping modern life.

Students will investigate each of these program areas in depth, focusing on such topics as the natural history of the river and its flora and fauna; the water cycle; the effects of physical and chemical properties on water quality and the organisms inhabiting a water body; the many uses of water and the importance of water conservation; drinking water and wastewater treatment; and cultures and settlements along the Ohio River Valley from ancient times to the present.

The guide is organized to provide maximum flexibility and ease of use for teachers of all grade levels. Each objective listed above constitutes a unit, which is further broken down into two to four sections covering specific topics. The components of each unit are as follows:

1. **Unit opener page.** Each unit opens with a page that describes the major sections, introducing the topics to be covered and the types of activities that students will encounter.
2. **Section background information.** Each section opens with several pages of background reading that prepare the teacher for presenting the activities in that section.
3. **Resources.** Following the background information are two lists of resources—publications and audiovisual programs—that can be used as valuable classroom references for particular activities or to broaden teacher knowledge.

4. **Activities.** The activities are the heart of the curriculum. Each section includes three to eight activities that allow students to explore the topics covered in the section. Each activity contains the following elements:

   - **Objective.** What students will accomplish by completing the activity and what skills they will use.
   - **Setting.** Where the activity should be performed (usually either in the classroom or outdoors).
   - **Duration.** Approximately how long the activity will take.
   - **Subject.** What academic subjects the activity encompasses.
   - **Skills.** What cognitive or behavioral skills students will exercise by performing the activity.
   - **Grade Level.** The grade level range for which the activity is designed.
   - **Vocabulary.** Which new terms students will need to know to understand the concepts presented in the activity. Vocabulary words appear in boldface type where they are introduced in the section background information. They are also defined in a glossary at the back of the guide.
   - **Background Information.** Where to look in the section background information to review the concepts being presented.
   - **Materials.** Equipment and/or resources needed to perform the activity.
   - **Procedure.** How to perform the activity. The procedure is described in a series of numbered steps, often including suggested discussion questions or alternatives for tailoring the activity to specific needs.
   - **Extension/Evaluation.** Suggestions for additional related activities that expand upon or enrich the concepts learned or that test students' mastery of these concepts.

   In addition, many activities are accompanied by maps, diagrams, clip art, and other handouts, which immediately follow the activity to which they pertain.

The curriculum also contains several additional tools designed to enhance the use of the activities. **Tables 1 and 2** (on the following pages) provide cross references to activities by grade level and by academic subject area, respectively, so that teachers can easily select projects suited to their needs. At the back of the curriculum, **Appendix A**, "Keeping Classroom Aquaria—A Simple Guide for the Teacher," provides step-by-step instructions for setting up and maintaining an aquarium so that students can study aquatic life firsthand. **Appendix B**, "Field Ethics: Determining What, Where, and Whether or Not!" discusses the ethical decisions regarding whether or not to collect, and how to do so with minimal impact to the environment. **Appendix C**, "Guidelines for Interviewing People," presents helpful hints on conducting interviews to obtain information from experts or to gain historical context for specific projects.

The last item in the curriculum is a glossary of words that are presented in the activities as new vocabulary. As mentioned earlier, these words also appear in boldface type as they are introduced in the background information for each section.

Table 1

Activities by Grade Level

The grade levels suggested below for each activity are intended as general guidelines. Many of the activities may be easily adapted for higher or lower grade levels or for more or less advanced students.

ACTIVITY	GRADE K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IA													
How Big Is the River—Really? (p. 12)					✓	✓	✓	✓	✓				
Make an Imaginary River System (p. 16)	✓	✓	✓	✓	✓	✓	✓						
How Rivers Are Formed (p. 18)				✓	✓	✓	✓	✓	✓				
Making a Glacier (p. 20)	✓	✓	✓	✓									
What Lived Here? (p. 22)						✓	✓	✓	✓	✓	✓	✓	✓
UNIT IB													
Water Wings (p. 32)	✓	✓	✓	✓	✓	✓	✓						
Designing a Habitat (p. 35)			✓	✓	✓	✓	✓						
Pieces of the Puzzle (p. 38)					✓	✓	✓	✓	✓				
Ohio River Wetlands (p. 40)								✓	✓	✓	✓	✓	✓
Wetlands Trivia (p. 43)							✓	✓	✓	✓	✓	✓	✓

Table 1 (cont'd)

ACTIVITY	GRADE												
	K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IC													
Water Plant Art (p. 53)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Life Stages (p. 56)				✓	✓	✓	✓						
Field Observations of Aquatic Organisms (p. 62)					✓	✓	✓	✓	✓	✓	✓	✓	✓
Wildlife Flash Cards (p. 66)				✓	✓	✓	✓	✓	✓				
Plaster Casts of Animal Tracks (p. 68)						✓	✓	✓	✓	✓	✓	✓	✓
Wetlands Safari (p. 71)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Endangered Species Poster (p. 74)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
UNIT IIA													
Water, Water Everywhere (p. 85)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
How Wet Is Our Planet? (p. 87)					✓	✓	✓	✓					
The Never-Ending Cycle of Water (p. 91)				✓	✓	✓	✓	✓	✓				

Table 1 (cont'd)

ACTIVITY	GRADE K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IIB													
A Change in the Weather (p. 101)					✓	✓	✓	✓	✓				
In Hot Water (p. 104)							✓	✓	✓	✓	✓		
Pondering pH (p. 107)				✓	✓	✓	✓	✓	✓				
The Disappearing Act (p. 111)					✓	✓	✓	✓	✓	✓			
Go with the Flow (p. 114)							✓	✓	✓	✓	✓	✓	✓
Life at the Surface (p. 117)					✓	✓	✓	✓	✓	✓	✓		
Dirty Water (p. 119)					✓	✓	✓	✓	✓	✓	✓		
Stream Study (p. 121)							✓	✓	✓	✓	✓	✓	✓
UNIT IIIA													
Water Use Collage (p. 133)	✓	✓	✓										
Where Does Our Water Come From? (p. 135)				✓	✓	✓	✓						
Model Distribution System (p. 138)				✓	✓	✓	✓	✓	✓				
Water Audit (p. 140)								✓	✓	✓	✓	✓	✓

Table 1 (cont'd)

ACTIVITY	K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IIIB													
Losing Soil (p. 156)		✓	✓	✓	✓	✓	✓						
Sinking In: Development and Flooding (p. 159)	✓	✓	✓	✓	✓								
Ohio River Navigation Locks and Dams (p. 161)					✓	✓	✓						
Who Pollutes the River? (p. 164)		✓	✓	✓	✓	✓	✓						
Ground-Water Model (p. 167)				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Power Valley and the Impacts of Acid Rain (p. 171)					✓	✓	✓	✓	✓	✓	✓	✓	✓
Problems with Litter (p. 174)					✓	✓	✓	✓	✓	✓	✓	✓	✓
UNIT IIIC													
Looking at Algae (p. 186)				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
How Clean Are Your Hands? (p. 189)										✓	✓	✓	✓
Function of Filters (p. 191)	✓	✓	✓	✓	✓	✓	✓						
How Water Is Cleaned (p. 193)								✓	✓	✓	✓	✓	✓

Table 1 (cont'd)

ACTIVITY	GRADE K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IIID Planning for the Future (p. 205)	✓	✓	✓	✓	✓	✓	✓						
Careers on the River (p. 209)							✓	✓	✓	✓	✓	✓	✓
Whose Job Is It? (p. 211)			✓	✓	✓	✓	✓						
Who Wants to Pay? (p. 213)			✓	✓	✓	✓	✓						
To Develop or Not to Develop? (p. 215)							✓	✓	✓	✓			
Pollution Detectives (p. 217)								✓	✓	✓	✓	✓	✓
UNIT IVA Archeological Sites (p. 230)						✓	✓	✓	✓				
Artifacts from the Past (p. 238)				✓	✓								
Let's Prepare an Ancient Indian Feast (p. 242)	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Who Were the Mound Builders? (p. 244)										✓	✓	✓	✓

Table 1 (cont'd)

ACTIVITY	GRADE												
	K	1	2	3	4	5	6	7	8	9	10	11	12
UNIT IVB Ohio River Place Names (p. 253)				✓	✓	✓							
The Shape of Our Town (p. 256)					✓	✓	✓						
Examining Local Economies of Current Ohio River Communities (p. 258)							✓	✓	✓	✓	✓		
Tales of the River (p. 261)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Watered Down History (p. 263)								✓	✓	✓	✓		

Table 2

Activities by Subject Area

Activities are categorized by subject area according to subjects generally taught at the grade levels recommended for those activities. For example, science activities geared toward the elementary grade levels will be categorized as "Science," rather than as "Biology" or "Chemistry." However, a science activity which spans a wide range of grade levels might be categorized as both "Science" and "Biology."

ACTIVITY	SUBJECT														
	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IA															
How Big Is the River—Really? (p. 12)						✓								✓	✓
Make an Imaginary River System (p. 16)	✓									✓					✓
How Rivers Are Formed (p. 18)						✓								✓	
Making a Glacier (p. 20)														✓	✓
What Lived Here? (p. 22)									✓					✓	✓
UNIT IB															
Water Wings (p. 32)	✓									✓		✓			
Designing a Habitat (p. 35)	✓									✓				✓	
Pieces of the Puzzle (p. 38)	✓	✓			✓					✓				✓	
Ohio River Wetlands (p. 40)	✓	✓		✓	✓		✓								✓
Wetlands Trivia (p. 43)		✓			✓		✓							✓	

Table 2 (cont'd)

ACTIVITY	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IC															
Water Plant Art (p. 53)	✓	✓												✓	
Life Stages (p. 56)														✓	
Field Observations of Aquatic Organisms (p. 62)	✓	✓			✓					✓				✓	
Wildlife Flash Cards (p. 66)		✓												✓	
Plaster Casts of Animal Tracks (p. 68)	✓	✓												✓	
Wetlands Safari (p. 71)											✓			✓	
Endangered Species Poster (p. 74)	✓									✓				✓	✓
UNIT IIA															
Water, Water Everywhere (p. 85)										✓				✓	✓
How Wet Is Our Planet? (p. 87)											✓			✓	
The Never-Ending Cycle of Water (p. 91)														✓	

Table 2 (cont'd)

ACTIVITY	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IIB															
A Change in the Weather (p. 101)			✓								✓			✓	
In Hot Water (p. 104)			✓								✓			✓	
Pondering pH (p. 107)														✓	
The Disappearing Act (p. 111)			✓								✓			✓	
Go with the Flow (p. 114)											✓		✓	✓	
Life at the Surface (p. 117)	✓									✓	✓		✓	✓	
Dirty Water (p. 119)			✓								✓			✓	
Stream Study (p. 121)		✓	✓											✓	
UNIT IIIA															
Water Use Collage (p. 133)	✓													✓	✓
Where Does Our Water Come From? (p. 135)	✓													✓	✓
Model Distribution System (p. 138)	✓													✓	✓
Water Audit (p. 140)				✓							✓			✓	

Table 2 (cont'd)

ACTIVITY	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IIIB															
Losing Soil (p. 156)														✓	
Sinking In: Development and Flooding (p. 159)														✓	✓
Ohio River Navigation Locks and Dams (p. 161)											✓				✓
Who Pollutes the River? (p. 164)										✓				✓	✓
Ground-Water Model (p. 167)														✓	
Power Valley and the Impacts of Acid Rain (p. 171)			✓											✓	✓
Problems with Litter (p. 174)														✓	✓
UNIT IIIC															
Looking at Algae (p. 186)	✓	✓						✓						✓	
How Clean Are Your Hands? (p. 189)		✓						✓							
Function of Filters (p. 191)														✓	
How Water Is Cleaned (p. 193)			✓					✓						✓	✓

Table 2 (cont'd)

ACTIVITY	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IIID Planning for the Future (p. 205)	✓														✓
Careers on the River (p. 209)	✓				✓										✓
Whose Job Is It? (p. 211)														✓	✓
Who Wants to Pay? (p. 213)											✓			✓	✓
To Develop or Not to Develop? (p. 215)				✓	✓										✓
Pollution Detectives (p. 217)							✓							✓	✓
UNIT IVA Archeological Sites (p. 230)															✓
Artifacts from the Past (p. 238)															✓
Let's Prepare an Ancient Indian Feast (p. 242)								✓							✓
Who Were the Mound Builders? (p. 244)									✓						✓

Table 2 (cont'd)

ACTIVITY	Art	Biology	Chemistry	Economics	English	Geography	Government	Health	History	Language Arts	Mathematics	Music	Physics	Science	Social Studies
UNIT IVB Ohio River Place Names (p. 253)										✓				✓	✓
The Shape of Our Town (p. 256)															✓
Examining Local Economies of Current Ohio River Communities (p. 258)				✓					✓						✓
Tales of the River (p. 261)					✓				✓			✓			✓
Watered Down History (p. 263)				✓		✓			✓						

Table of Contents

The Ohio River and the Total Ecosystem

The Ohio River and the Total Ecosystem

This unit introduces students to the Ohio River and its watershed, and describes their function as an ecosystem for an abundance of plant and animal life. *Section A* presents a brief geologic history of the region from the Ice Age tens of thousands of years ago to today, and describes the river's current extent and geographical features. Activities focus on identifying the Ohio River Basin as a geographical region, speculating on the role of glaciers in carving out the Ohio River Valley, and exploring the evolution of rivers and river features in general. Primary emphasis is given to helping students to understand that the Ohio River ecosystem encompasses not only the river itself, but the floodplain and watershed that depend on it for life.

Section B begins by defining ecosystems and describing the interrelationships among their living and nonliving components. The section then focuses in more detail on some of the specialized habitats that can be found along the Ohio River, in particular, the riparian and wetland environments. Activities allow students to experience ecosystems firsthand using the senses of sight, touch, and hearing, and to form an aesthetic appreciation of these natural environments and their own connection to them. Students will also perform research to learn about the significance of wetlands and the threats facing them.

In *Section C*, students will have an opportunity to familiarize themselves with the variety of plant and animal life, including endangered wildlife, that lives in the fertile environment of the Ohio River Basin. Several activities allow students to venture into the field on expeditions to observe and, in some cases, collect for more detailed study, samples of macroscopic and microscopic life. In one activity, students will use resources in the classroom to study the life stages of different organisms, and in another, students will use aquatic plants to create works of art that can also serve as educational tools. One of the last activities in the unit sends students out into a nearby habitat to make a survey of the plants and animals they find there and to draw conclusions about the interrelationships among these forms of life based on their observations.

A The Ohio River and Its Watershed

1 The Waters of the Ohio River

The Ohio River begins where the Allegheny River and the Monongahela River waters meet and merge, at Pittsburgh, Pennsylvania. As the Ohio River flows westward, numerous **tributaries**, or smaller rivers and streams that flow into a larger river, join it. Some of these are Beaver River, Scioto River, Licking River, Great Miami River, Kentucky River, Green River, Wabash River, Cumberland River, and the Tennessee River. Each of these rivers have also collected water from hundreds of smaller creeks and streams, which they add to the Ohio River. When the Ohio River reaches Cairo, Illinois, it too joins another river, becoming a tributary to the even larger Mississippi River.

An aerial view or drawing of a river system such as this often resembles the branches of a tree. The particular shape of the pattern is determined by the elevation of the land and the underlying rock layers in the area. Sometimes the waters swell or shrink in response to flooding or drought. The land area along a stream that is periodically flooded when the stream overflows its banks is the river's **floodplain**.

The great land area covered by the pattern of branching waters is known as the **drainage basin or watershed**. The Ohio River's drainage basin reaches as far north as New York State, and as far south as Alabama. The river system draws its water, not only from the tributaries that flow into it, but also from rain and snowmelt that wash over the land and run into it from the watershed. Water that washes over the surface of the land is known as surface runoff (see Unit II, Section A-2).

Changes in the drainage basin, even those occurring 100 miles away from the river itself, can and will affect it. As rain and snowmelt flow across the land and into the river, they wash over everything in their path—city streets, farms, parking lots, lawns, and forests. They pick up and carry loose material on the way. When rainwater washes pesticides and fertilizers off lawns and farms, the chemicals end up in the river. When construction in the river's drainage basin causes heavy soil erosion, the silt is carried toward the river. Other examples include polluters dumping waste into a small stream, which flows to the river. When tributaries are channelized or not permitted to overflow into their natural floodplains, the river receives all of the flood water and is more likely to rage out of control.

On the other hand, positive changes in the drainage basin will also be reflected in the quality of the river. When small streams are cleaned up, their clean water helps flush and cleanse the river. When trees are planted to hold rainwater and soil in place, the river's burden of silt decreases. When small streams, during heavy rains, are permitted to overflow in many small floodplains, the river's flow is moderated.

For good or bad, the river is affected by what happens throughout its watershed. And these effects do not end with the Ohio River. Because the Ohio is a tributary of the Mississippi River, these effects continue into another river system and onward to the Gulf of Mexico and the ocean. Since all oceans are connected and water flows from one to the other, what happens on a small tributary of the Ohio River may eventually affect the ocean environment worldwide.

2 The Geologic History and Evolution of the Ohio River

The Ohio River of today runs through six states beginning in Pennsylvania and flowing through Ohio, West Virginia, Indiana, Kentucky, and Illinois. The river, however, has not always flowed such a great distance or through the same valleys. Two million years ago a series of glaciers, massive sheets of moving ice formed by the compaction of snow over long periods of time, caused dramatic changes in the topography of this region. The glaciers came down from Canada spreading southward through Ohio, Indiana, and northern Kentucky. Acting as mighty bulldozers, they picked up soil and rocks and transported them from north to south. Material, such as dirt and rocks, which is picked up and moved by glaciers is known as glacial till. Glacial till as well as the glaciers themselves frequently acted as dams forcing streams to change direction or find new routes, thus carving new valleys. Glaciers were a primary force in shaping the Ohio River region as it looks today.

One way to look at the changes that have occurred to the Ohio River Basin is as nature recycling the landscape. We have learned to recycle and reuse materials such as bottles, cans, plastic, and paper, but nature has been recycling the very ground beneath our feet for millions of years. The rolling uplands of the Greater Cincinnati area, its hills and valleys, and its rivers and streams, all give evidence that the landforms of the region have been recycled not once, but several times in the last 2 million years.

Many of the most dramatic changes came about during the period of Earth's history called the **Pleistocene Epoch** or the **Ice Age**. Three glaciers changed the shape of the Ohio River Basin: the Kansan (over 1 million years ago), the Illinoian (about 400,000 years ago), and the Wisconsinan (about 70,000 years ago). Before the first major ice sheet arrived in the region, the area was a gently rolling plain. Figure IA-1 shows what the river system in this area might have looked like in pre-glacial time. From the illustration, one can see that the Teays River (to the north) and the Ohio River (to the south) were the two major streams that drained the area of the present day Ohio River Basin. These streams both flowed westward toward the Mississippi River. A huge bedrock formation called the Silurian Escarpment (shown by the dotted line in the diagram) formed a divide that controlled the direction of flow and separated the waters of the Ohio from the Teays.

At this time, the waters did not originate in Pennsylvania, as they do today. Glaciers that covered western Ohio and eastern Indiana dammed the streams and forced the waters to merge and be routed through new valleys, substantially lengthening the course of what would become the modern-day Ohio River.

The Kansan Glaciation. When the first of these major ice sheets, the Kansan, moved from the north over the Cincinnati area, the Teays River was dammed by the advancing glacier (Figure IA-2). In time, lake waters created by the dam overflowed and the streams cut new courses. The Ohio River gradually evolved along the edge of the glacier, formed by a patchwork of the courses of former streams.

As the Kansan ice sheet melted, water continued to follow the new drainage system westward from near Hamilton, Ohio, as far southwest as Louisville, Kentucky. Augmented by a large volume of meltwater and accompanying higher velocity, this new river recycled former valleys, eroding a deep, wide channel called the Deep Stage Ohio. The Teays, which had drained much of the eastern and southeastern United States, ceased to exist. Most of its former channel now lies buried under 400 feet of glacial till. Only in southern Ohio and northern Kentucky, where the glaciers never reached, is the Teays valley still visible.

The Illinoian Glaciation. The next ice sheet, the Illinoian, advanced from the northeast (out of Ontario, Canada) and covered almost all of southwestern Ohio. There were two lobes of ice, an eastern lobe called the Clermont and a western lobe called the Harrison (see Figure IA-3). The Harrison advanced southward down the lowland of the Scioto River toward Chillicothe and then southwestward to Cincinnati. At the same time, the Clermont lobe pushed down along the Indiana-

Ohio border into western Hamilton County. The area west of Mill Creek lay between two ice tongues.

The Illinoian ice sheet eventually dammed the Deep Stage Ohio. Thus, a second lake formed, extending back up the Deep Stage Ohio toward Portsmouth to the east and along the Deep Stage Licking to the south. As time passed, the lake rose higher and higher; in due course it spilled over directly westward from Cincinnati, cutting a new, narrow gorge extending through Anderson Ferry, Sayler Park, and on to North Bend. This breaching of the divide caused the waters east of Cincinnati to merge with those west of Cincinnati, to form the present-day Ohio River.

The Illinoian glacier continued to creep southwestward, depositing a blanket of till over the lake clays. For upwards of 300,000 years following the retreat of this glacier from Ohio, weathering and erosion of these glacial deposits continued to carve new valleys and form terraces that are still visible along the Mill Creek and under Bond Hill, Norwood, and Mariemont.

The Wisconsinan Glaciation. The last continental glacier advanced into southwestern Ohio about 70,000 years ago. This glacier also had two lobes, the Miami to the west and the Scioto to the east, and stayed at its maximum extent for several hundred years (Figure IA-4). When the glacier retreated, it left a rolling belt of till marking the terminus of glacial movement. A segment of this terminal moraine, called the Hartwell Moraine, extends westward in Ohio from just east of Pisgah to Sharon Woods, then south along the sides of the former Deep Stage valley, north to Winton Woods and Greenhills, and westward to the Indiana border. As the glacier melted, great braided streams of meltwater carried large quantities of sand and gravel from as far away as Ontario. Many of the valleys became filled with stratified deposits of the material, which erosion has since cut into terraces along many of the valleys. (Figure IA-5 shows a profile of the Ohio River Valley today, with its many stratified layers resulting from the glacial activity.)

Animal Life of the Pleistocene Epoch. Excavations in glacial deposits from the Wisconsinan ice sheet reveal that the Ohio River Basin was home to a multitude of animal life during this period that was very different from the animal life today. Bones, teeth, and other fossils of many **extinct** animals which roamed the glacial and interglacial countryside have been uncovered. Two giant relatives of the modern-day elephant—the **mammoth** and the **mastodon**—lived here in the past. Other animals that resembled present-day species include giant ground sloths, wild horses, giant beavers, peccaries, tapirs, and giant bison.

3 Changes in the Modern Ohio

Even today, the shape of the Ohio River continues to shift and change, although not as dramatically as during the Ice Age. As the river moves along its floodplain gathering more water from tributaries, it gradually slows and becomes wider and more winding. In these later, or "older," stages, the river begins to flow on a thick accumulation of **alluvium**, or material transported and deposited by the river in earlier stages of its activity. One characteristic of an alluvial river is that it frequently rises over its banks and floods annually or once every 2 years during the season of largest water surplus in the watershed. Overbank flooding normally inundates part or all of a floodplain.

On the alluvial plain, the river winds and curves, increasing its curves by eroding the bank on the outer edge and depositing material on the shallower inner edge. The curves, or **meanders**, eventually develop narrow necks, which are finally cut through as the water breaks through the banks to take the shortest route. This event is called a cutoff. It is followed quickly by deposition of silt and sand across the ends of the abandoned channel, producing an **oxbow lake**. The oxbow lake is in turn gradually filled in with fine sediments brought in during high floods and with organic matter produced by aquatic plants. The oxbow lake is thus eventually converted into an oxbow swamp. The various stages of this process are illustrated in Figure IA-6.

Resources

Publications

Durrell, R. 1961. A Recycled Landscape. Cincinnati, OH: Cincinnati Museum of Natural History. 9p.

Kaufmann, J.S., R.C. Knott, and L. Bergman. River Cutters: Teacher's Guide. Great Explorations in Math and Science (GEMS). Berkeley, CA: Lawrence Hall of Science, University of California, Berkeley.

Lafferty, M.B., ed. 1979. Ohio's Natural Heritage. Columbus, OH: The Ohio Academy of Science. Produced jointly by The Ohio Academy of Science and the Ohio Department of Natural Resources.

Ray, L. 1974. Geomorphology and Quaternary Geology of the Glaciated Ohio River Valley—A Reconnaissance Study. Geological Survey Professional Paper 826. Washington, DC: U.S. Government Printing Office. 74p.

Strahler, A. and A. Strahler. 1987. Modern Physical Geography, 3rd ed. New York, NY: John Wiley and Sons.

Resources *(continued)*

Audiovisual Programs

The River: A First Film. Phoenix Films, Inc. (BFA Educational Media), 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. Presents how rivers are formed, where they get their water, and how cities use rivers for their water (11 minutes). Primary and intermediate grades.

River Channel Forms. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. Analyzes the dynamic nature of rivers and the relationship between their forms and processes (20 minutes). Rental fee: $75.

Rivers to the Sea. Bullfrog Films, Oley, PA 19547, 1-800-543-FROG. Explores the abundant life in Atlantic Rivers with some spectacular underwater footage. Stresses the role that humans play in river ecology (46 minutes). Grades 7 to adult. Rental fee: $75.

The World of a River. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Illustrates aspects of a river system and the characteristics of the animals and plants found therein. Slide show. Cost: $79.95.

Unit I, Section A-2 was adapted with permission from: Durrell, R., A Recycled Landscape (Cincinnati, OH: Cincinnati Museum of Natural History, 1961).

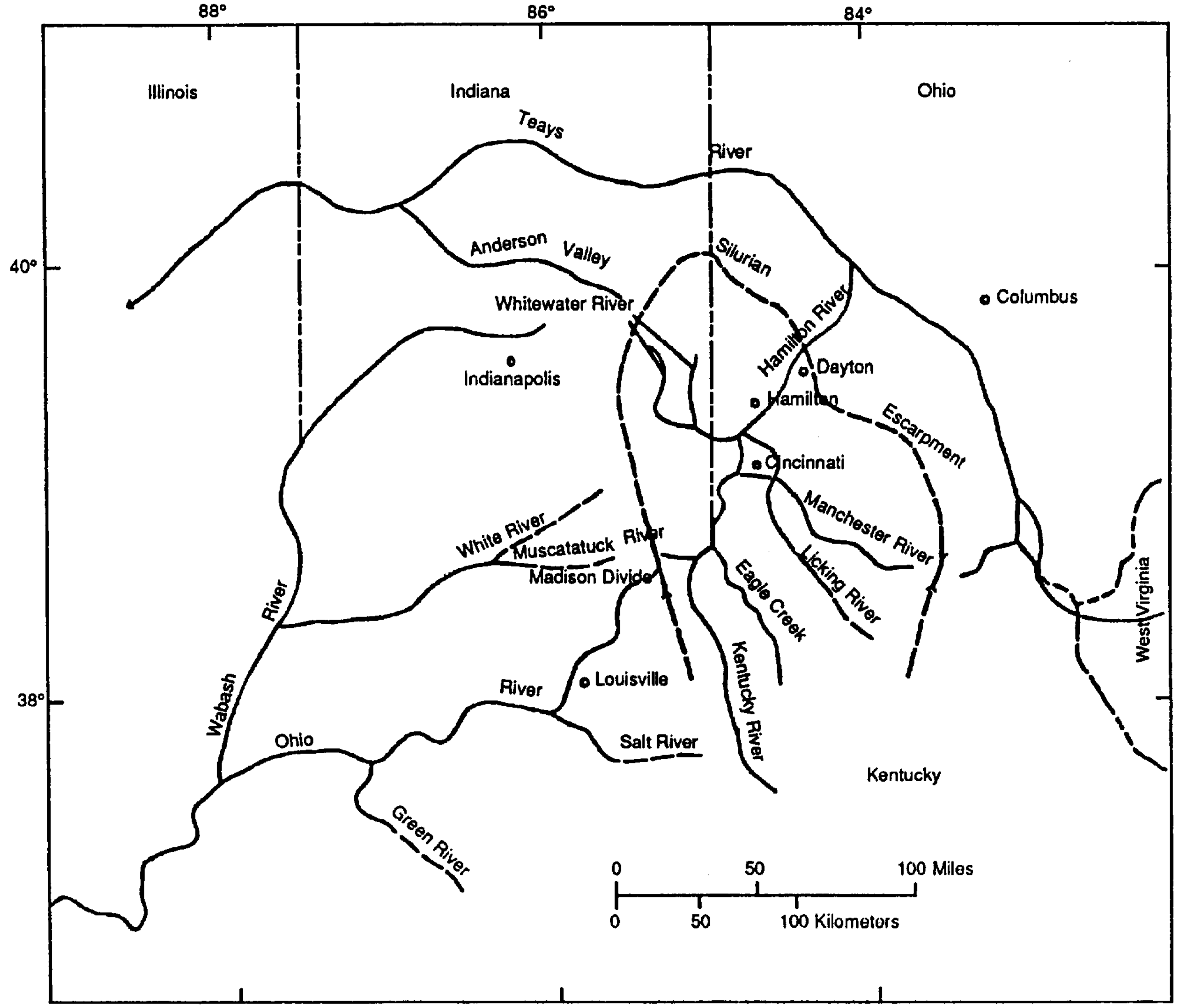


Figure IA-1. Pre-glacial river system in the Ohio River Valley.

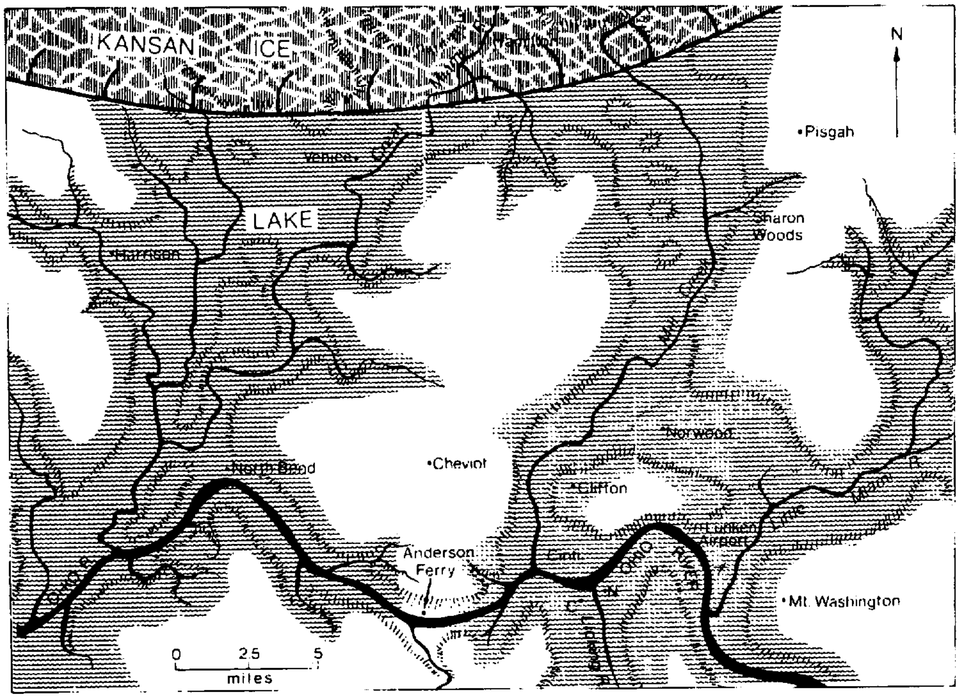


Figure IA-2. The Kansan glaciation.

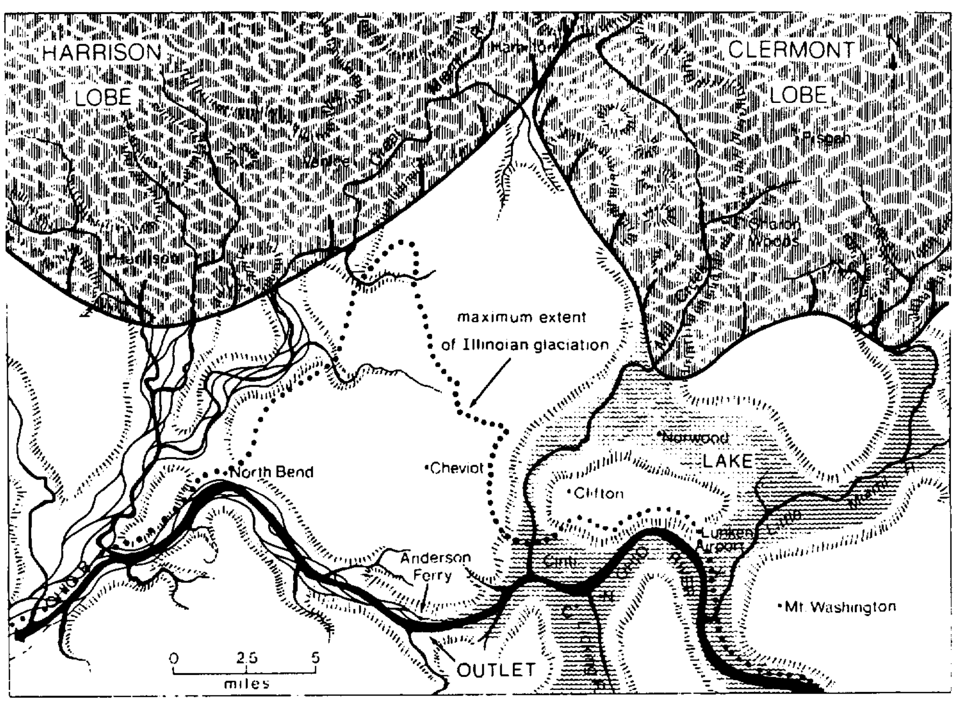


Figure IA-3. The Illinoian glaciation.

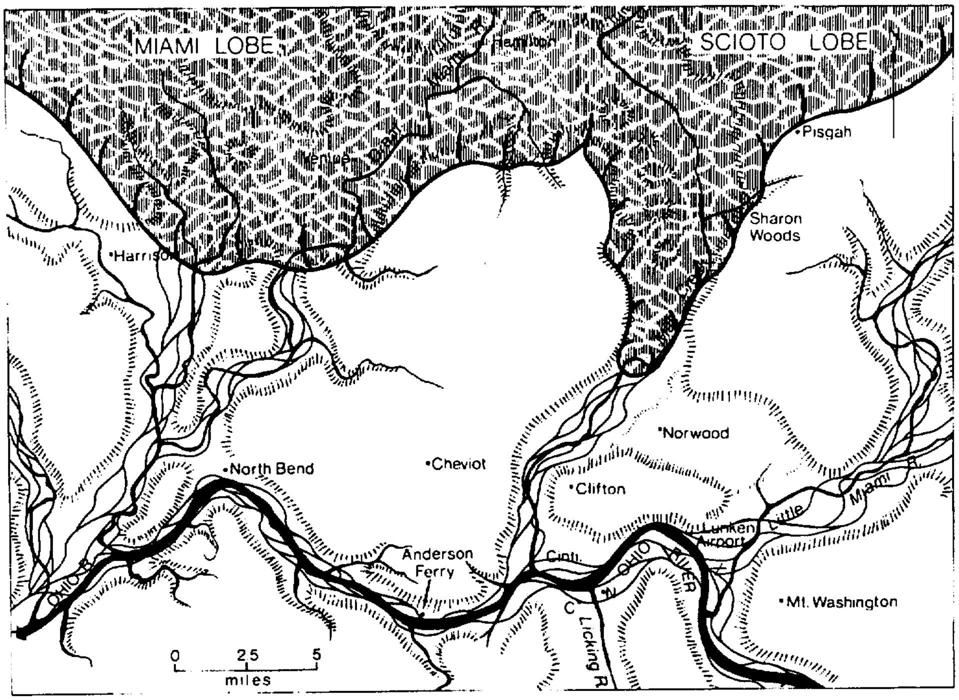


Figure IA-4. The Wisconsinan glaciation.

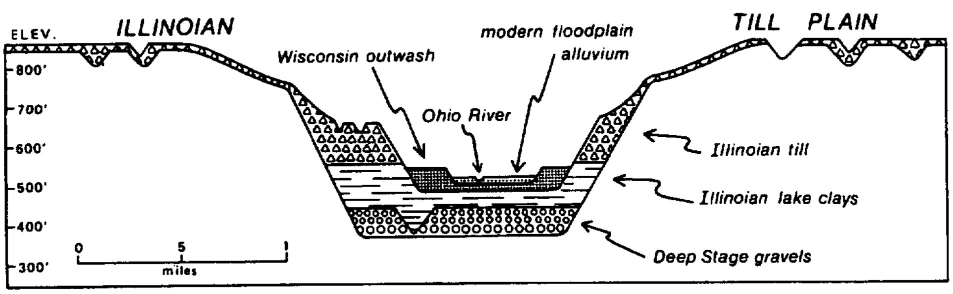
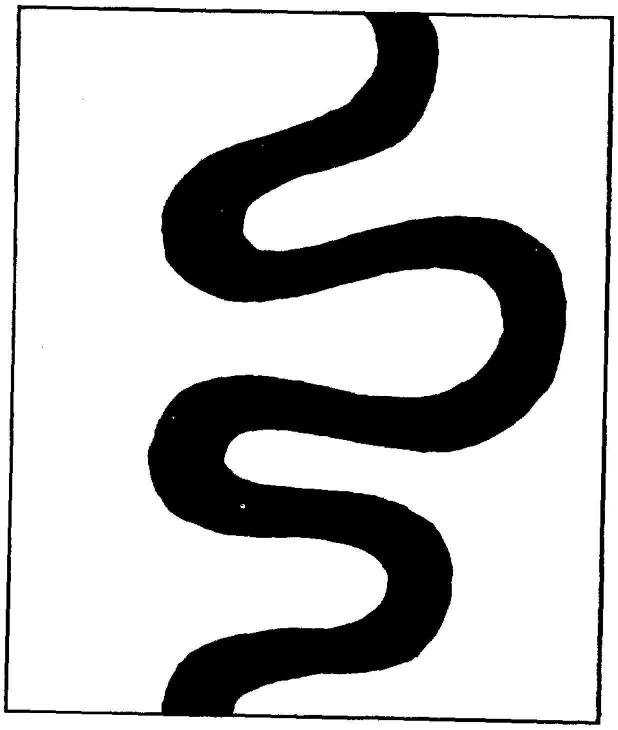
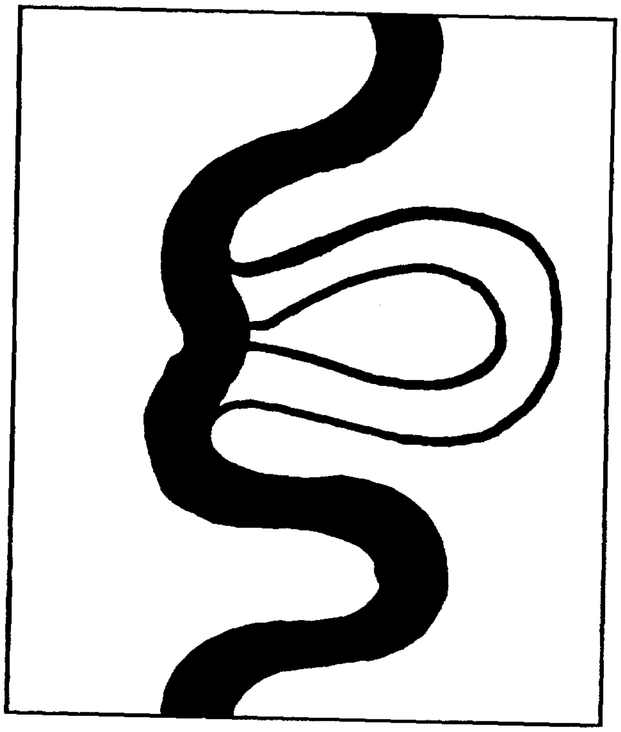


Figure IA-5. Profile of the modern Ohio River Valley.

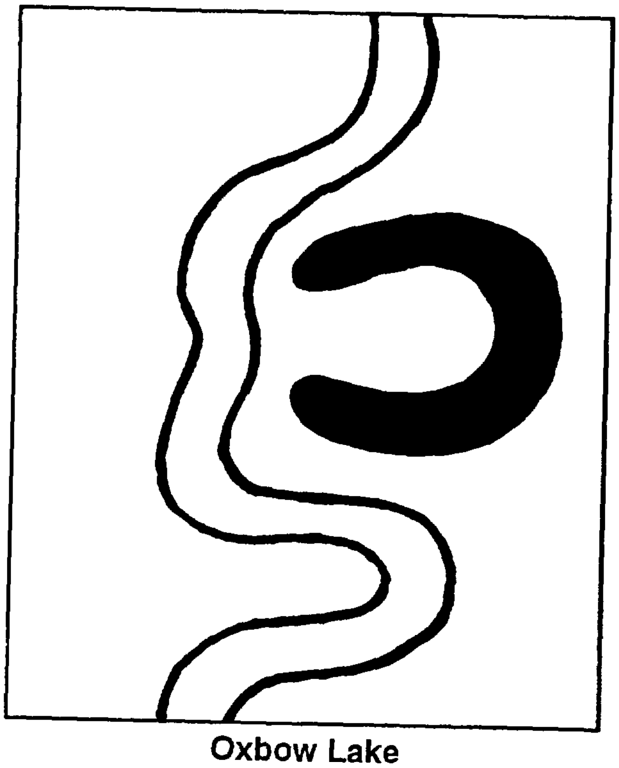
Figure IA-6. Stages in an alluvial river.



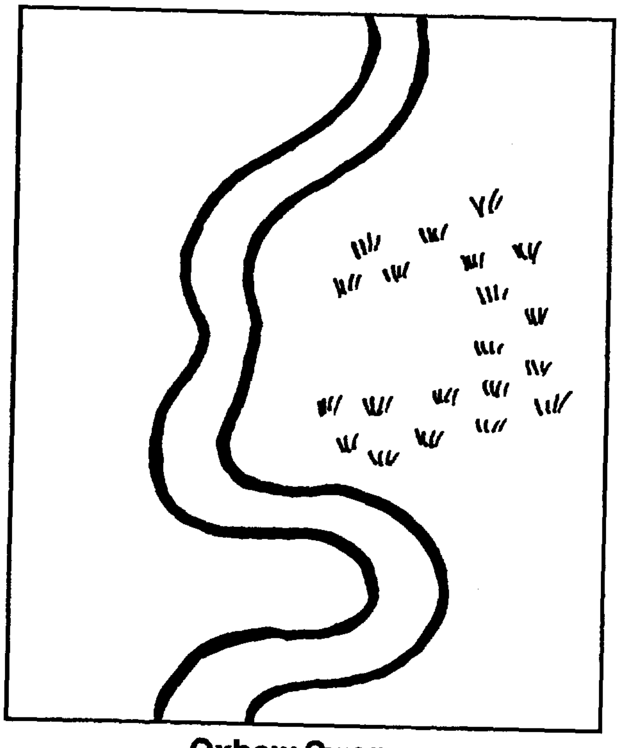
Meander



Cutoff



Oxbow Lake



Oxbow Swamp

A

Activity

How Big Is the River—Really?

Objective

Students will be able to define the concept of watershed, identify the Ohio River's watershed system, and describe the immediate watershed in which they live.

Setting

Indoors

Duration

Two 1/2 hour sessions

Subject

Geography, Science, Social Studies

Skills

Mapping, Discussion, Drawing, Inference, Identification

Grade Level

4-8

Vocabulary

watershed tributary floodplain drainage basin

Background Information

Refer to Unit I, Section A-1.

Materials

- Copies of the Ohio River Watershed map handout for each member of the class and/or copies of travel maps of the states in the Ohio River system (Illinois, Ohio, Indiana, Kentucky, West Virginia, Pennsylvania, New York, and North Carolina) posted at the front of the classroom. A large map of the United States showing the Ohio River and its tributaries would also be helpful.
- Copies of local maps for each student.
- Crayons or markers, and colored pencils.

(Automobile clubs have detailed maps. Hydrologic maps, which show water systems, are available from the state Geologic Survey.)

Procedure

Part 1

With the individual maps or with the large travel maps or the map of the United States:

1. Have students locate the Ohio River and trace over it with a marker or crayon.
2. Have students locate the rivers that join to form the beginning of the Ohio and trace over them.

Procedure

(continued)

3. Have students locate tributaries along the Ohio, and trace them back to their origins or as far back as possible.

4. If topographical maps are available, ask students to tell in what direction the water is flowing and how they know.

Discuss with students how many states the Ohio River flows through and from how many different states the river gets its water. Have students speculate about how the waters of the Ohio River system connect these different states (transportation, commerce, fishing, drinking water supply, water quality). Ask them to think about how things that happen in one state along the river could affect other states in the river system. Some possible topics are dams, factories dumping pollutants, or cleanup projects.

Part 2

Explain the concept of watershed. Using the maps from the previous exercise, explain that a watershed is an area of land from which rain and snowmelt drain into a particular stream or river. Watersheds may consist of small areas of land that drain water into small streams or huge areas of land that drain water into large rivers. Watersheds are usually named after the river they drain into. Ask students to find and indicate the Ohio River watershed on the map. Reinforce the idea that all of the land in a watershed is connected.

Tell students that they will learn about the smaller watershed in which they live.

On a state or local map:

1. Have students find their own town or community on the map.
2. On tracing paper, have students find and trace the section or tributary of the Ohio River that flows closest to them.
3. With different colored pencil or marker trace all of the different rivers and streams in their area.
4. With a third color, have them draw a line around their watershed.

Ask students:

- What types of things might rainwater flow over in your area (roads, parking lots, farms, lawns)?
- How might this affect the water in the watershed's rivers and streams (fertilizers, pesticides, silt, pollutants could run into the river)?

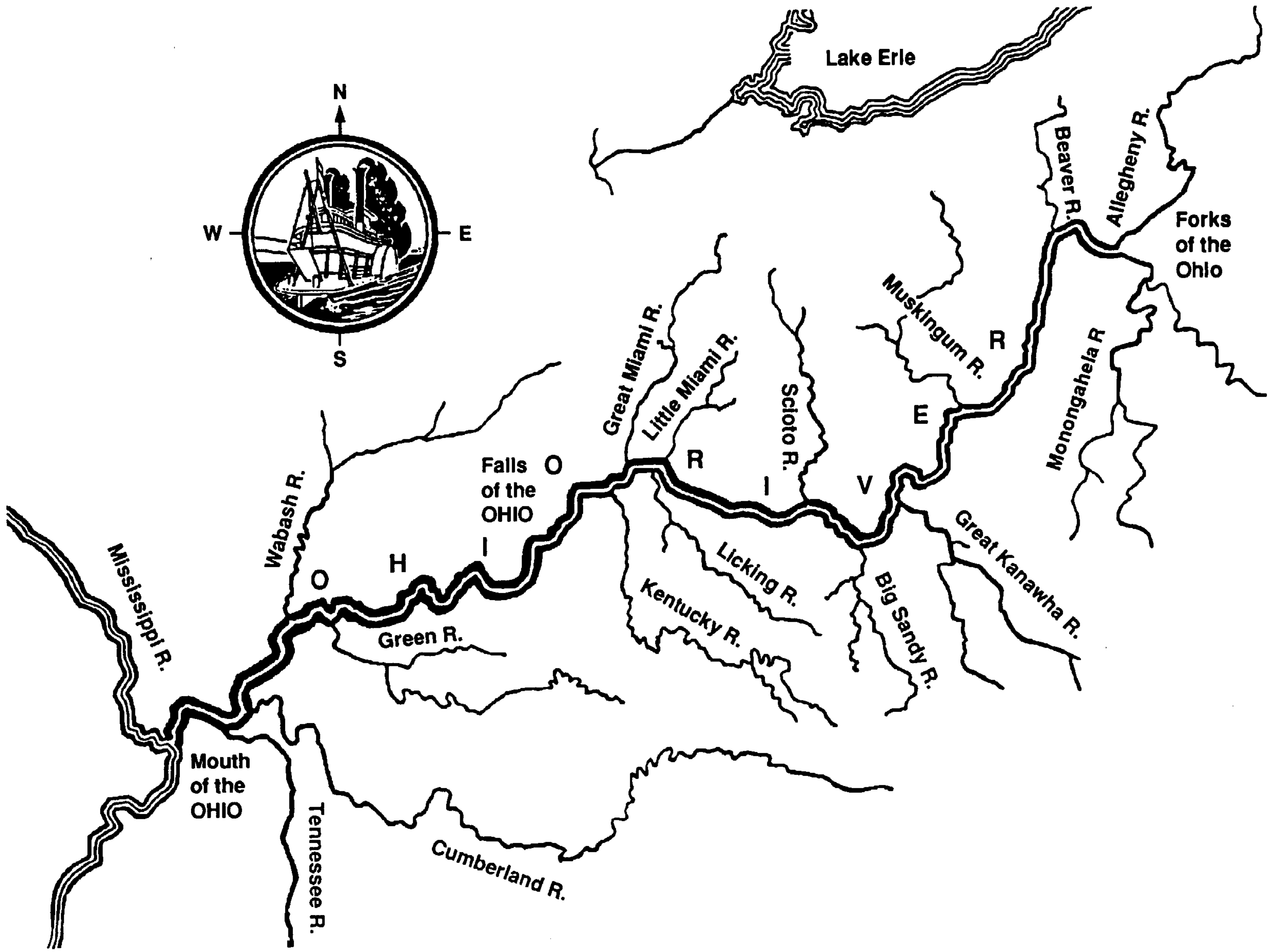
Procedure *(continued)*

- How might what happens in their watershed affect others?
- Where does all of the water eventually go?

Extension/ Evaluation

Have students identify the states and rivers that make up the Ohio River watershed. Students should be able to explain how the different states and waters of the Ohio River watershed are interconnected and together make up the area called the Ohio River. Have them draw an imaginary river system, labeling the sources and tributaries of the river, and outlining and naming the watershed.

Ohio River Watershed



A

Activity

Make an Imaginary River System

Objective Students will construct their own miniature river systems and be able to explain the concepts of watersheds and tributaries.

Setting Indoors

Duration One 1/2 hour art session and one 1-hour creative writing assignment

Subject Art, Language Arts, Social Studies

Skills Writing, Psychomotor Development, Observation, Comparing Similarities and Differences, Inference, Discussion, Media Construction

Grade Level K-6

Vocabulary tributary floodplain

Background Information Refer to Unit I, Section A-1.

Materials

- Construction paper.
- Nontoxic, water soluble ink or thin paint.
- Straws.
- Newspaper, aprons, and protective covers for furniture and children.

Procedure In preparation for this activity, cover furniture and outfit children with smocks or other protective clothing. Cover working surfaces with newspaper.

1. Pass out a piece of art paper and a straw to each student.
2. Put a small puddle (several drops) of ink or paint at the edge of each piece of paper.
3. Have students blow directly onto the ink or paint through the straw. Be sure that student is blowing into the side of the drop from the same level as the paper, not down on top of the drop. The ink/paint drop should spread out in a branching pattern similar to that of a river and its tributaries.

Procedure *(continued)*

4. Tell students that they have made an imaginary river system. The force of their breath served as the wind or a force of nature to make the paint/ink (river source) drain or run onto other areas of the paper (land). They should name their river and its major tributaries. Have students label their work with their name and the name of the system and put it aside to dry.

For homework, ask students to think about whether their rivers are "wild" or "settled." If settled, are there any towns or cities along the river and its tributaries? Any natural areas? How do people who live in the river system use the water?

Conclude with a discussion of what other forces of nature (rain or snow storms, mountains, gravity, glaciers) might act upon water to form a river system.

Extension/ Evaluation

When the paint or ink is dry, you may wish to extend this activity into a creative writing assignment. Have students reclaim their "river system" maps, and label them with the names of rivers, towns, and cities. Encourage students to show where mountains or hills might be located around the watershed boundaries and label them accordingly.

Encourage students to write a story or travel piece about their river system. Have them pretend they are trying to encourage people to come and visit the area. Below are some questions they might want to ask to get themselves started.

- What do the natural areas within the watershed look like? These could include forests, lakes, streams, marshes, or valleys.
- What animals and plants live in the watershed?
- What is the history of the towns and cities in the watershed? Who settled there and why? (Encourage students to use their imaginations.)
- How do people use the river today? Include recreational and commercial uses.

A

Activity

How Rivers Are Formed

Objective
Students will create models of rivers, identify river features, and compare their models to actual rivers.

Setting
Classroom or laboratory

Duration
One 40- to 60-minute period

Subject
Geography, Science

Skills
Recording Data, Media Construction, Psychomotor Development, Small Group Work, Decision-Making, Inference, Communication, Comparing Similarities and Differences

Grade Level
3-8 (Conduct as a demonstration for younger students.)

Vocabulary
tributaries meanders alluvium cutoff oxbow lake

Background Information
Refer to Unit I, Sections A-1 through A-3.

Materials
- Sand table/sand box.
- Pitcher or other container of water.
- Paper and pencil.

Procedure
Explain to students that they will be creating miniature rivers in this demonstration. Break older students into small groups to perform the activity, if space and materials permit. For younger students, perform the demonstration yourself.

1. Mound the sand or soil into a small hill.
2. Pour water slowly onto the sand or soil.
3. Have students draw a picture of what they see.
4. Have students identify the source of the river and its mouth, then label these features on their diagrams.
5. Ask students if they can identify other river features. If students are not already familiar with tributaries, meanders, oxbow lakes, cutoffs, and other features, allow time for them to research in geology textbooks or other reference materials.

Procedure *(continued)*

6. Have students label their diagrams with any additional river features, then discuss what they have found.

Extension/ Evaluation

Have students experiment with different slopes in the sand boxes and different water flows to see the effect on the formation of their rivers. Encourage students to draw pictures of rivers formed on shallower and steeper slopes and with faster and slower flows. Compare these rivers and discuss the differences.

If there is a river area nearby where students can observe the formation of oxbows, waterfalls, deltas, meanders, or other river features, arrange a field trip.

A

Activity

Making a Glacier

Objective

Students will observe how a glacier could have moved and infer how glaciers might have changed the landscape.

Setting

Indoors

Duration

15 minutes

Subject

Science, Social Studies

Skills

Observation, Discussion, Comparing Similarities and Differences, Inference

Grade Level

K-4

Vocabulary

glacier glacial till Ice Age

Background Information

Refer to Unit I, Section A-2.

Materials

- Chocolate swirl (marble) ice cream.
- Chocolate chip cookies.
- Marshmallow syrup.
- Plastic glove or lunch bag.
- Baking sheet or pan.
- Cups or bowls, and spoons (optional).

Procedure

Explain to children that you will be showing them a process similar to what happened in the Ohio River Basin hundreds of thousands of years ago.

1. Crumble the cookies onto the baking sheet or pan. The crumbled cookies represent glacial till, materials such as rocks and dirt that are picked up and moved by the force of a glacier.
2. Remove ice cream from container and place it on top of the cookies. Explain that the ice cream represents the glacier. Although a glacier begins as clean snow, as it travels, it picks up dirt and rocks so that it becomes streaked with dirt. The swirls in the ice cream represent the "dirt" in the glacier.

Procedure *(continued)*

3. Place a plastic lunch bag or glove over your hand, and compact the ice cream. Have children notice the cookies sticking to the ice cream. As more and more ice and snow fall on the glacier, the weight causes it to ooze, pushing the glacial till (cookies) in all directions and carrying some along with it. Emphasize that this process takes thousands of years.
4. To see how glaciers moved (or oozed), warm up the marshmallow syrup or add a little hot water to make the syrup slightly runny. Then pour the syrup over the ice cream.
5. Have students observe the movement of the "glacier," and try to relate this movement to the way a real glacier might have traveled.

You could now divide up the ice cream "glacier" into cups or bowls for all of the children.

Extension/ Evaluation

Ask children to explain the process by which a rock found in their schoolyard might have been moved and deposited by a glacier a half a million years ago. If there is a glacier-carved valley or evidence of glacial till in your area, you may wish to arrange a field trip for children to observe the work of a real glacier firsthand.

A

Activity

What Lived Here?

Objective

Students will learn through research that, along with the changing landscape, the plant and animal life of the Ohio River Basin has changed dramatically over time.

Setting

Classroom and library

Duration

Two to three 40-minute periods for research; 5 minutes of classroom presentation per student

Subject

History, Science, Social Studies

Skills

Research, Writing, Public Speaking, Reading

Grade Level

5-12

Vocabulary

extinct fossils mammoth mastodon Ice Age Pleistocene Epoch

Background Information

Refer to Unit I, Section A-2.

Materials

The research for this activity should take place in a library, unless you can stock the classroom with enough books on the Ice Age and prehistoric animals. You will also need pictures of the modern-day descendents of prehistoric animals, such as elephants, wild horses, sloths, tapirs, and bison.

Procedure

1. Show students pictures of the following animals or put them up on the board: elephants, wild horses, sloths, tapirs, bison.
2. Have students identify where these animals live in the world today. Then explain to them that thousands of years ago, animals similar to these species lived in the areas covered by the Ohio River Basin.
3. Have students choose a prehistoric animal (mammoth, mastodon, giant ground sloth, wild horses, giant beaver, peccaries, tapirs, bison) to research. They should prepare a 5-minute presentation for the class on where these animals used to live, when they lived, what they looked like (including how they differed from their modern-day descendents), what they ate, who their enemies were, how they became extinct (if known), and how we have learned this information about them.

Extension/ Evaluation

Students may wish to form small groups to create dioramas or murals of what the Pleistocene Age in the Ohio River Basin might have looked like, including glacial features and prehistoric plants and animals.

Arrange a field trip to a local museum that has a display on this time period, such as the Ice Age exhibit at the Cincinnati Museum Center.

B The Ohio River as an Ecosystem

1 What Is an Ecosystem?

Ecology is the science concerned with the interrelationships among living things and their environment. The word ecosystem combines two words: ecology and system. It connects the idea of ecology, or the study of nature, with a system, a set of interactions over time among various parts. An ecosystem can be as small as a piece of rotting bark or as large as a desert. The Ohio river (or any river) can also be seen as an ecosystem. The plants and animals that live and grow on the river's banks and shorelines, and the aquatic life (fish, plants, algae, bacteria) found within the river itself would all be part of the river ecosystem. These would all be part of the biotic or living component within the river ecosystem. Also included in the river ecosystem are the soil, rocks, water, and other nonliving matter, which make up the abiotic component.

Every system also needs one more thing to set it in motion—the addition of energy. In nature, this energy comes in the form of light, usually from the sun. If the sun is the "engine" driving the ecosystem, the plants are the "factories" where that energy is captured and processed into a usable form by photosynthesis. Photosynthesis is the process that occurs in the chloroplasts of green plants, in which simple sugars (glucose) are formed from carbon dioxide and water in the presence of light and chlorophyll (a pigment that gives plants their green color). (See also Unit II, Section A-4.) Plants break down glucose stored in their cells to obtain energy. Oxygen is released as a byproduct of this process. This basic reaction is:

$$\underset{\text{carbon dioxide}}{(CO_2)} + \underset{\text{water}}{(H_2O)} + \text{sun} = \underset{\text{glucose}}{(C_6H_{12}O_6)} + \underset{\text{oxygen}}{(O_2)}$$

Because plants are able to manufacture their own food, something animals cannot do, they are known as producers or autotrophs. Animals are called heterotrophs, meaning that they get their food from other organisms. Animals that feed on plants directly are known as **herbivores** (plant eaters) or primary consumers. Not all animals eat plants, however; many get their energy by eating other animals that have fed on plants. These are known as secondary consumers. And animals that feed on secondary consumers are known as tertiary consumers. Secondary and tertiary consumers are both **carnivores** (flesh eaters). In addition, many animals, for example humans, may eat both plants and flesh from other animals. Such animals are known as **omnivores**. A diagram showing these relationships among producers and consumers is a **food chain**. An example of a food chain might consist of an eagle eating a fish that has eaten a frog that has eaten insects that have eaten plants.

To complete the food chain, however, still another set of organisms is needed, special consumers known as **decomposers**. Decomposers (such as bacteria and fungi) live by breaking down matter such as fallen trees and branches, dead animals, and rotting leaves into simpler compounds. Decomposition completes the food chain by returning or recycling needed nutrients back into the system so that they can be used once again by the producers.

The constant interactions of all of these living and nonliving elements over time make up the ecosystem. At a global level, all of the elements on the planet interact. But in practical terms, it is useful to consider groups of organisms interacting in a relatively direct way as an ecosystem.

2 Components of Habitat

The environment in which an animal lives is called its **habitat**. There are many different types of habitat in the ecosystem that comprises the Ohio River Basin. Each habitat, however, contains a very specific arrangement of components that allow the plants and animals that live there to survive. An animal's habitat includes food, water, shelter, and adequate space in an arrangement appropriate to the animal's needs. If any of these components of habitat are missing or are altered significantly, the animal will be affected.

The basic life-giving conditions of food, shelter, air, water, and space in a suitable arrangment are basic to the survival of all animals. For animals in aquatic environments, however, the water is a uniquely sensitive part of the habitat and must serve to do far more than merely quench thirst. The water must meet specific requirements for different forms of aquatic life. For example, slight changes in salinity, temperature, sunlight, or dissolved oxygen can spell disaster for certain aquatic organisms. Some animals prefer deep water and others rocky shallow bottoms. Some creatures thrive in the rushing, tumbling waters of brooks and streams, while others need the calm, still waters of a lake or pond. (For more information on physical and chemical properties of water, see Unit II, Section B.)

3 The Ecosystem of the Ohio River Basin

A river's ecosystem includes the plants, animals, soils, and other non-living elements along its banks as well as in its waters. It is important to realize that the Ohio River does not exist in isolation. It is simply the biggest, most obvious part of a system that collects and carries water from an area thousands of square miles in extent.

The river is also intimately tied to the riparian habitat along its edges. The riparian community is a distinctive plant community that thrives at the edges of flowing water. These plants in turn support particular wildlife species. Riparian environments have several characteristics that make them unique habitats for wildlife. Leaf litter and terrestrial insects falling from vegetation into a stream are a source of detritus, providing nourishment for some aquatic life. The riparian plant community, especially trees and shrubs, provides food for animals as large as deer and as small as insects. Trees and marshy areas provide shelter for nesting birds and river banks provide homes for burrowing animals. Vegetation may also provide shade from the sun for aquatic plants and animals and for land-dwelling creatures at the water's edge. Riparian zones often provide different and more abundant vegetation than surrounding areas, resulting in a higher percentage of shade, higher humidity, and more diversity in animals and plants.

The riparian community also benefits the river directly. Roots and vegetation hold soil on the river banks, preventing erosion and siltation, and helping to keep the water clear. The vegetation cleanses runoff water before it enters the river. The plant community also acts as a "sponge," holding excess water during high-volume times and releasing it to the river when the flow is lower.

In turn, the river continually nourishes the riparian community and during floods brings additional nutrients to the soil. The waters also provide transportation for seeds, helping the riparian environment spread and replenish itself. Without the nearby river water, the riparian plant community would disappear causing changes in the associated wildlife populations.

To truly understand the Ohio River, one cannot study just the water and organisms on its banks. The river is an inseparable part of a larger ecosystem that includes the riparian community and the drainage basin from which its waters flow.

4 Wetlands and Their Importance

Although this large ecosystem is connected by the common link—the Ohio River—many different habitats are traversed by the river's course, from fertile farmland to marshes teeming with wildlife. The Ohio River today is largely a series of long pools behind navigation locks and dams, located in a deep carved valley. Yet the lower reaches of the river, below Louisville, have an extremely wide floodplain, with many meanders and cutoffs, which create extensive wetlands.

Wetland is a general term describing land that is sometimes or always wet. Wetlands are important "in-between" places located between open water and dry land. A wetland is an area that supports predominantly aquatic vegetation and hydric (wet) soils, and is permanently or seasonally saturated with water. Wetlands may take the form of **marshes, wet meadows, swamps, bogs, oxbows,** and similar areas. Some wetlands stay wet all year, while others may be seasonal, drying out during summer and fall months. Each of these areas is different in the types of life it supports and thus each represents a unique habitat in the total ecosystem of the Ohio River.

The wetlands and floodplains of the Ohio River Basin serve as a natural system for flood control, water purification, ground-water recharge, soil and riverbank erosion control, and wildlife food chains and habitat. Wetlands and floodplains can be compared to giant sponges, soaking up the overflow of a flooding river, storing and delaying floodwater, trapping sediments for the river water, and allowing the water to seep slowly into the underground water table or aquifer. Aquifers provide drinking water for the small communities of the Ohio River Basin. (For more information on ground water, aquifers, and drinking water, see Unit II, Section A, and Unit III, Sections B and C.)

Wetlands also provide breeding and wintering grounds for millions of **migratory** waterfowl and shorebirds. During the northern spring migration of waterfowl, Ohio River Basin floodplains are often resting and feeding areas for ducks, geese, and swans of many species. These vernal (spring) wetlands may also become summer farmland on which corn and soybeans can be raised in the rich soils that the waters have left behind. Our coastal wetlands also provide nursery and spawning grounds for commercial fishing.

5 Threats to Wetlands

According to the U.S. Fish and Wildlife Service, the United States has lost more than half of the 200 million acres of wetlands that were originally present in the lower 48 states when European settlement began. The country continues to lose between 300,000 and 500,000 acres of wetlands every year. During the past 200 years, many wetlands in our country have been drained because these areas were considered wastelands—useless swamps and marshes serving as sources of mosquitoes and flies. Agriculture has been responsible for a vast amount of wetland losses, as farmers have drained wetlands to plant crops. Wetlands also have been drained and filled in as cities, towns, and industries have expanded.

Wetlands have become shopping centers, highways, and housing developments. They have also been damaged from too much pollution from agriculture, industry, and development. Nearly one-third of the nation's endangered and threatened species of plants and animals live in wetlands as well.

6 Wetlands Protection

Our nation is now coming to realize that wetlands have great value in their natural state, and they are now protected by laws. Two of the most effective wetland protection programs are the Duck Stamp program and Section 404 of the Clean Water Act (CWA). The Duck Stamp program, administered by the U.S. Fish and Wildlife Service (FWS), raises money to help buy valuable wetland habitats. Section 404 of the CWA helps prevent wetland destruction through a carefully controlled permit program. Under guidelines established by the U.S. Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers evaluates wetland projects, hears comments from citizens and private interest groups (as well as local, state, and federal agencies), and then decides whether or not to grant a permit to the developer.

Other important laws protecting wetlands include Section 10 of the River and Harbors Act of 1899, which requires the Army Corps of Engineers to review and authorize a permit before any structure can be built, waterway altered, or material deposited or excavated in a navigable waterway. In 1985, the Federal Food Security Act required that federal subsidies be revoked for farming wetlands. This legislation is known as the "Swampbuster Provision." The Emergency Wetlands Resources Act of 1986 directs the FWS to develop National Wetlands Inventory to map the nation's wetlands. In 1989, the National Wetlands Policy Forum, at the request of EPA, released a report called "Protecting America's Wetlands: An Action Agenda" calling for "No net loss of wetlands." This request was issued publicly by President George Bush in asking for cooperative wetlands protection by all federal agencies, such as EPA, the U.S. Department of Agriculture, the Soil Conservation Service, FWS, and the Army Corps of Engineers. Many states have now passed or are considering legislation to protect wetlands. There is currently much debate over proposed legislation in the U.S. Congress that would redefine wetlands. If passed, this legislation could allow development on millions of acres previously protected under CWA amendments.

7 A Cooperative Effort

The "Oxbow area" is an example of an Ohio River wetland that is in trouble. This 2,500 acre area is found at the confluence of the Great Miami and Ohio Rivers in southwestern Ohio and southeastern Indiana. In 1985, political and business leaders announced plans to create a major new port authority and barge shipping center on this floodplain. This idea seemed to make economic sense to some, but others knew that the Oxbow area was already serving as an invaluable resource for wildlife habitat, flood control, and water purification. The Oxbow has long been used by people for hunting, fishing, birdwatching, and farming.

In 1986, a volunteer citizens' group, Oxbow, Inc., was formed with the help of local Audubon Society and Sierra Club members and other conservationists. Oxbow, Inc. members began writing letters and calling their state representatives to urge protection for this important natural area. Once legislators understood the complex nature of the Oxbow and its value for wildlife, they dropped plans for the port authority and barge facility. Presently, over 1,000 citizen members of Oxbow, Inc. are continuing to work for the protection of the Oxbow area. With the cooperation of the Hamilton County Park District, the Ohio and Indiana Departments of Natural Resources, and local land owners, 1,373 acres have been protected, either by outright purchase or conservation easement. Oxbow, Inc. continues to present public information programs, to do valuable wetland research, and to work with officials of the FWS and U.S. Army Corps of Engineers to restore lost habitat. The Oxbow story is a good example of citizens working together with federal, state, and local governments to save vital habitats.

Resources

Publications

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Heller, R. et al. 1973. Challenges to Science: Earth Science. New York, NY: Webster Division, McGraw Hill Book Company.

Lafferty, M.B. 1979. Ohio's Natural Heritage. Columbus, OH: The Ohio Academy of Science. Produced jointly by The Ohio Academy of Science and the Ohio Department of Natural Resources.

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U.S. Department of Agriculture. 1988. Conservation and the Water Cycle. Agriculture Information Bulletin No. 326. 0-521-909: QL 3. Washington, DC: U.S. Government Printing Office.

Usinger, R. L. 1967. The Life of Rivers and Streams. New York, NY: McGraw-Hill Book Company. Developed jointly with The World Book Encyclopedia.

Western Regional Environmental Education Council. 1987. Aquatic Project Wild. For more information, contact Western Regional Environmental Education Council, P.O. Box 18060, Boulder, CO 80308-8060, 303-444-2390.

Audiovisual Programs

America's Wetlands. New York State Department of Environmental Conservation, Audiovisual Services, Film Loan Library, 50 Wolf Road, Room 516, Albany, NY 12233-4501, 518-457-0858. Free rental.

Conserving America's Wetlands. National Wildlife Federation, 1400 16th St. NW, Washington, DC 20036-2266, 1-800-432-6564. Filmstrips or slides: $26.95.

Resources *(continued)*

The Ecosystem: Network of Life. Phoenix Films, Inc. (BFA Educational Media), 468 Park Ave. South, New York, NY 10016, 1-800-221-1274. Explores the interactions that take place between living things, and between organisms and the physical elements in the environment (11 minutes). Junior and senior high levels.

Freshwater Biology. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Describes a freshwater environment with examples of food chains. Slide show. Cost: $39.95.

Freshwater and Salt Marshes. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Describes and illustrates the various types of marshes, how marshes are formed, and the plants and animals common to these wetland habitats. Video or slide show.

Water. Bullfrog Films, Oley, PA 19547, 1-800-543-FROG. An examination of freshwater ecosystems, and the effects of damming and diversion (59 minutes). Grades 7-12.

Wetlands and Pinelands. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. A study of wetland ecosystems from the Pine Barrens of New Jersey to areas of Mexico and Belize, where environmental planning are recognizing the role of humans in the ecosystem (38 minutes). Rental: $75.

B

Activity

Water Wings

Objective

Students will learn to identify water-related sounds and their sources within an ecosystem. They will also explore their own thoughts and feelings about aquatic environments through visualization and creative writing.

Setting

Outdoors or in a classroom

Duration

One 20-minute listening session and one 40-minute period for art or creative writing

Subject

Art, Language Arts, Music

Skills

Listening, Visualization, Creative Writing

Grade Level

K-6

Vocabulary

ecosystem aquatic

Background Information

Refer to Unit I, Sections B-1 through B-3.

Materials

- Tape-recordings of water sounds or of an aquatic habitat such as a river, lake, stream, swamp, or marsh. (You can either make these tapes yourself or obtain them from bookstores, music stores, or stores that specialize in nature.)
- Art materials, including water-based paints (i.e., acrylic, water color, or poster paints), brushes, paper, containers for water.
- Writing materials.

Procedure

1. Play the tape for the children. The first time, have them listen quietly and try to picture a setting for the sounds they hear. Have them concentrate on the quality of the sounds, but ask them not to write or draw anything while the tape is playing.
2. Now play the tape a second time. This time, have children in grades 2-6 write down the names of things they think are making the sounds they hear. For children in grades K-1, have them say the names of things they hear as they listen, while you write them on the board.

Procedure *(continued)*

3. Ask children to name some of the things they wrote down (e.g., rain, bird songs, frogs croaking, a waterfall, a beaver's tail slapping). Ask children where and when they think the sounds might have been recorded (e.g., a marsh during a storm, a river early in the morning). Have children justify their choices.
4. Ask children to close their eyes and try to recreate the picture in their minds that was created by the sounds. What do they see? Tell them to imagine as much detail as possible, the colors, the plants and animals, the sky. If you feel it would be helpful, you may play the recording again.
5. Now tell children they will be painting a picture of the scene they have just been listening to. Provide the art materials and ask them to include all of the things that they heard and saw when they closed their eyes. Alternatively, you may wish to have older children write short poems about what they heard. Some simple poetic forms are described below.

Haiku

Originated by the Japanese, haiku consists of three lines of five, seven, and five syllables each. The emphasis is syllabic, not rhyming. Here is an example:

The fish swam by me
Nothing left in the shimmer
My heart beat faster

Cinquain

Cinquain is derived from the French and Spanish words for five. This form of poetry is also based on syllables—or may be based on numbers of words. The parts are 1) the title in two syllables (or two words); 2) a description of the title in four syllables (or words); 3) a description of the action in six syllables (or words); 4) a description of a feeling in eight syllables (or words); and 5) another word for the title in two syllables (or words). Here is an example:

Osprey
Fishing eagle
Moves above dark water
With graceful strength it finds its meal
Seeker

Procedure *(continued)*

Diamante

Diamante is a poem shaped in the form of a diamond. It can be used to show that words are related through shades of meaning from one extreme to an opposite extreme, following a pattern of parts of speech like this:

noun
adjective adjective
participle participle participle
noun noun noun noun
participle participle participle
adjective adjective
noun

For example:

Stream
Small, clear
Rippling, moving, growing
Life, plants, animals, people
Rushing, sustaining, cleansing
Connected, universal
Ocean

You may wish to create a display of children's artwork and poetry on a bulletin board.

Extension/ Evaluation

Older students may enjoy going out into the field to tape record their own sounds. Take a field trip to a stream, pond, lake, river, or wetland where human-made sounds will be at a minimum. Divide students into groups and have them tape water-related sounds and write down what they have recorded. Later in the classroom, allow the different groups to play back their sounds so that the other groups can guess what they are.

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B

Activity

Designing a Habitat

Objective

Students will learn about the components of a habitat that are essential for the survival of aquatic animals by designing artificial habitats for particular species. Through this activity they will recognize and appreciate the complex life requirements of aquatic wildlife.

Setting

Classroom

Duration

Two or more 45-minute periods

Subject

Art, Language Arts, Science

Skills

Media Construction, Small Group Work, Public Speaking, Research, Interviewing, Writing

Grade Level

2-6

Vocabulary

aquatic habitat

Background Information

Refer to Unit I, Section B-1 and B-2.

Materials

- A set of 3 x 5 cards, each with the name of one of the following animals written on it: trout, river otter, largemouth bass, water strider, diving beetle, crayfish, leopard frog, moose, ruddy duck, great blue heron, and beaver (expand the choice as appropriate).
- Art supplies, including paints and brushes, paper mache, modeling clay, string, cardboard.
- Gallon jars for aquatic environments.
- Cardboard boxes for semi-aquatic environments.
- Field guides and other reference materials. (See Resources for Unit I, Sections B and C.)

Procedure

Explain to the class that to successfully house aquatic wildlife in zoos or aquaria, careful attention must be paid to the range of conditions each life form can tolerate. There are also certain physical requirements in terms of shape and dynamics of the display that must be compatible with each creature. For example, some fish require moving water or currents, while others prefer the still waters of lakes or ponds. Some animals prefer deep water, others shallow rocky bottoms, and still others marshes or swamps.

Procedure *(continued)*

1. Divide the class into groups of two or four. Have each group draw one card from a container.
2. Ask each group to design an artificial habitat in which its animal could live. Inform them that teams will be expected to conduct library research or consult reference materials or resource people to determine the life requirements of their creature. In addition, they must investigate and establish the characteristics of the natural habitat of the animal. They must be concerned not only with the basic life-giving conditions for survival, but must also pay attention to the animal's comfort. Their "aquaria" should be as similar to the animal's natural habitat as possible.
3. When the research is complete, each team of students should design and build a model of a zoo exhibit or aquarium habitat that would be suitable for its animal's survival and comfort. Have each group establish a scale for their exhibit (for example, 1 inch = 5 feet for the large animals; actual size for the insects).
4. Once the models are complete, ask each team to report to the rest of the class. Each report should include a description of the basic biological needs of the animal, as well as a description of the characteristics of its natural habitat. The students should point out how their models are designed to meet the needs of the animal.
5. Ask students to summarize the components of habitat that seem to be necessary for the survival of the aquatic animals they studied. (Food, shelter, and space in a suitable arrangement would be the minimum necessary components.)
6. OPTIONAL: You may wish to have students arrange their models in a plan for a zoo or aquarium, and invite other classes in to see their display.

Extension/ Evaluation

Visit an aquarium and arrange for a staff person to address the components of habitat and the basic requirements necessary to sustain the animals in healthy environments.

Create a balanced freshwater aquarium for the classroom. (Refer to Appendix A, "Keeping Classroom Aquaria—A Simple Guide for the Teacher.")

Extension/ Evaluation

(continued)

Discuss the reasons for and against keeping aquatic wildlife in captivity in zoos and aquaria. (Pros might include conservation, protection of endangered species, and environmental education; cons would be difficulties of survival and reproduction in captivity, disrupting the habitat and food chain by removing them from their original home, and changing their natural behavior.)

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B

Activity

Pieces of the Puzzle

Objective

Students will be able to define an ecosystem and arrange its components into a system that shows how they work together.

Setting

Outdoors, along a river bank or stream

Duration

1 hour

Subject

Art, Biology, English, Language Arts, Science

Skills

Listening, Observation, Listing, Discussion, Inference, Synthesis

Grade Level

4-8

Vocabulary

ecosystem riparian producers consumers herbivores carnivores decomposers omnivores

Background Information

Refer to Unit I, Sections B-1 through B-3. You may also wish to consult Chapter 11, "Ponds, Streams, and other Watery Places," in the book, *Nature with Children of all Ages* (Prentice-Hall Press, NY: Massachusetts Audubon Society, 1982).

Materials

Pencil and paper.

Procedure

Arrange a field trip to a stream or riverside where students will be free to observe and illustrate. (Potential field trip sites in the Cincinnati area include Fernbank Park on River Road, Shawnee Lookout County Park, Magish Recreation Area, and Little Miami Scenic River Park.)

1. Have students choose a spot in an area designated by you and make a list of all the living and nonliving things they can see in the area. Alternatively, you may wish to have students draw and label the things they see.
2. Bring students together and ask them to share their lists or drawings with others in the class. Discuss how some of these interact with one another or are related to one another. For example, for plants, you might have students consider questions such as:
   - What does a plant get from the soil?
   - Where does the soil get what the plant needs?
   - What else does the plant need to live?
   - Does anything eat the plant?

Procedure *(continued)*

3. Have students return to their spots. Tell them to close their eyes and use only their senses of hearing, smell, and touch to add to their lists.
4. Have students share any new observations with the class and discuss how these additional items are related to each other and to the things already on their lists.
5. Have students return to their spots a final time to look for signs of animals that may have passed through the area even if they are not there now. Such signs might include broken twigs, tracks, woodpecker holes, or animal burrows. Remind students that they also are animals. Have they seen any tracks or signs made by people? Have they themselves left any signs in the ecosystem? Do they notice any difference in the signs left by people and those left by other animals?
6. The final stage of the activity can be done at the field trip site or back in the classroom. Have students write a short essay describing the interrelationships of the components of the riparian ecosystem they have explored, reminding them to include all of the relevant items from their lists both living and nonliving. Alternatively, you may wish to provide students with drawing paper and have them draw a picture of the riparian ecosystem, labeling all of the parts they have observed.

Extension/ Evaluation

After returning to the classroom, you may wish to have students create a mural showing the animals, plants, and nonliving things in the ecosystem. They could draw arrows to show the connections between elements in the ecosystem or connect related components of the ecosystem with pieces of yarn.

If the area you visited was excessively damaged by human intrusion, you may wish to discuss with students how this damage could upset the balance of the ecosystem or keep it from functioning properly. Talk with students about what they could do to return the ecosystem to its natural state, and, if time and interest exists, revisit the area to take those steps.

B

Activity

Ohio River Wetlands

Objective

Students will perform research on and familiarize themselves with a particular wetland and present their information to the class in the form of an oral presentation.

Setting

Classroom and library

Duration

Several 40-minute class periods

Subject

Art, Biology, Economics, English, Government, Social Studies

Skills

Research, Writing, Public Speaking, Interviewing, Drawing

Grade Level

7-12

Vocabulary

wetland oxbow lake meander migratory floodplain

Background Information

Refer to Unit I, Sections B-4 through B-7. See also Unit I, Section A-4.

Materials

- Paper and pen or pencil.
- Reference materials, including field guides (see Resources for Unit I, Sections B and C).
- Copies of Ohio River Wetlands handout for each student.

Procedure

1. Define wetland and discuss different types of wetlands. Show pictures as you talk about different wetland environments.
2. Distribute handout showing major Ohio River wetlands, pointing out the uniqueness of the Oxbow at the mouth of the Great Miami River. In contrast to the many wetlands on the lower Ohio, the Oxbow is the only such ecosystem for a hundred miles around.
3. Have each student choose an Ohio River wetland to research. Each student's research should cover the wetland's:
   - Importance to wildlife.
   - Recreational significance.
   - Contribution to flood control and water quality.
   - Economic significance.
   - Current status of protection, including any regulations or legislation pertaining to the area.

Procedure

(continued)

4. Provide students with references, including addresses of Natural Resources Departments and natural areas from which information can be gathered (some of these addresses are listed below).

Note: Make sure that students write to these sources well in advance of the scheduled time for doing research in class.

5. Allow students several class periods to research their topics. Checkpoints for student progress can include reference lists, outlines, notecards, and draft reports.
6. Have students prepare written reports and present their findings to the class in the form of 15-minute oral presentations. The presentations should include visual aids including maps, photographs, overheads, charts, and illustrations of wildlife and habitat. If equipment is available, students may wish to develop their reports as video presentations.

Extension/ Evaluation

Take a field trip to one of the wetlands presented to the class. Have students keep in mind what they learned from the oral presentation as you explore the wetland as a class. Afterwards, discuss some of the points brought up in the presentation in the context of what you have seen. You may also wish to invite a speaker from Oxbow, Inc. or Little Miami, Inc. (addresses below) to come and talk about the importance of wetlands.

Additional Resources

The Ohio Valley. G. and E. Laycock. (Garden City, NY: Doubleday, 1983)

The Ohio River. J. Pearce and R. Nugent. (Lexington, KY: University Press of Kentucky, 1986)

Wetlands. Audubon Society Natural Guide, Oxbow, Inc.
2073 Harrison Avenue
Cincinnati, OH 45214
(513-948-8630)

Little Miami, Inc.
3012 Section Rd.
Cincinnati, OH 45237
(513-351-6400)

Ballard County Wildlife Management Area
R.R. 1
La Center, KY 42056

Henderson Sloughs
c/o Kentucky Department of Fish and Wildlife
Frankfurt, KY 40601

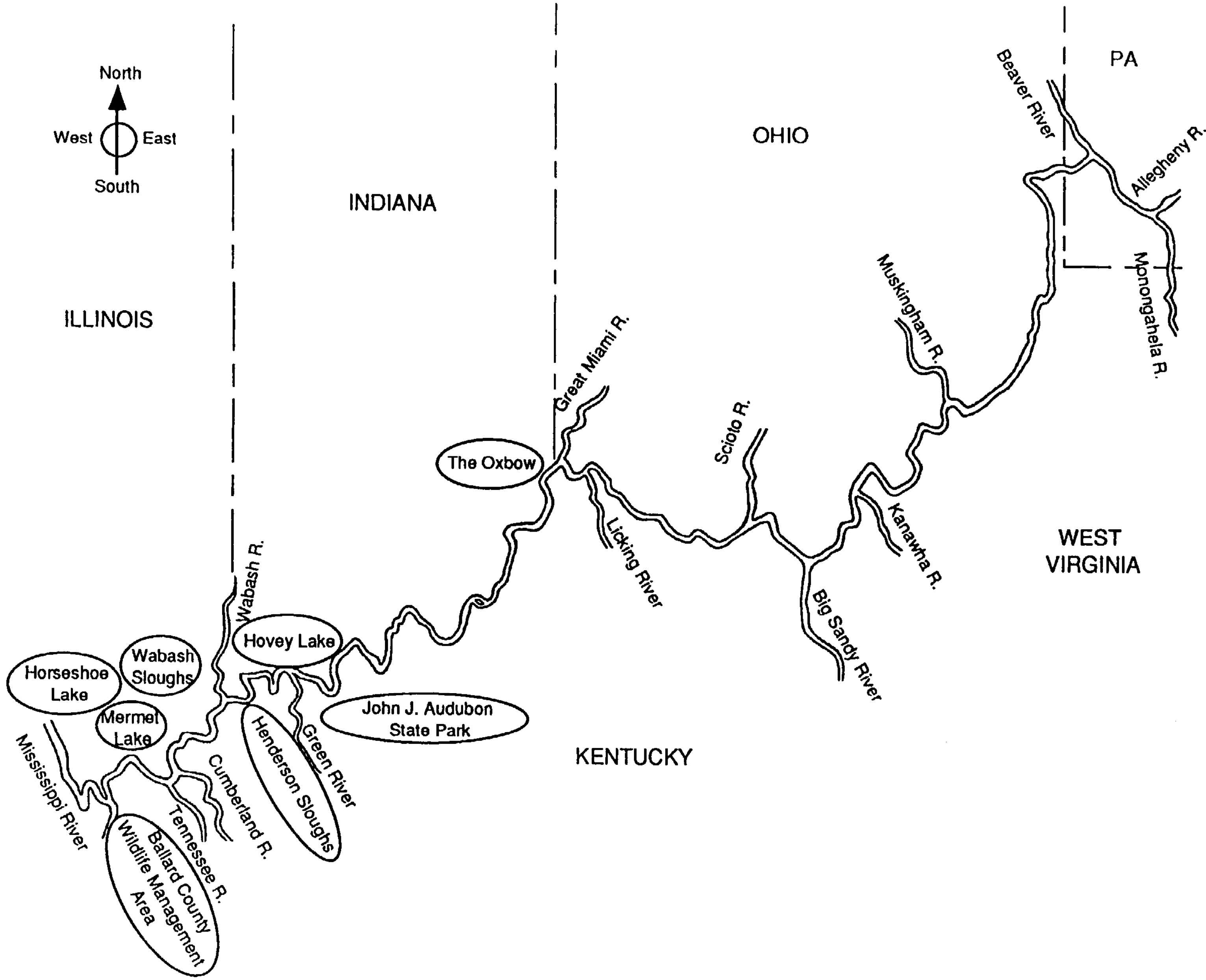
Horseshoe Lake Conservation Area
Highway 3
Cairo, IL 62969

Mermet Lake and Lower Wabash Sloughs
Illinois Department of Conservation
100 West Randolph Street
Chicago, IL 60601

John J. Audubon State Park
P.O. Box 576
Henderson, KY 42420

Hovey Lake State Fish and Wildlife Area
R.R. 5
Mt. Vernon, IN 47620

Ohio River Wetlands



B

Activity

Wetlands Trivia

Objective

Students will perform research to learn about wetlands, their significance, and threats facing them, then test their knowledge.

Setting

Classroom

Duration

Two 40-minute periods

Subject

Biology, English, Government, Science

Skills

Research, Writing, Reading, Synthesis, Application

Grade Level

6-12

Vocabulary

endangered marsh bog wet meadow swamp pollution threatened

Background Information

Refer to Unit I, Sections B-4 through B-7.

Materials

- Magazines, field guides, pamphlets, and other reference materials on different types of wetlands and their significance. This may include material on specific wetlands in your area and legislation affecting them. (See also Resources for Unit I, Sections B and C.)
- Index cards or cards made of construction paper.
- Writing materials.

Procedure

Session 1—Research

1. Present students with some background material on wetlands. Discuss some of the problems facing wetlands and encourage students to volunteer any information they know about local wetlands.
2. Tell students that they will be researching questions for a game called "Wetlands Trivia." Ask each student to come up with 10 questions (and answers) using the reference materials you have supplied in the classroom. Their questions should cover the following topic areas: wetland wildlife; benefits of wetlands including recreation, flood control, pollution control, wildlife habitat, drinking water; threats facing wetlands; and wetland protection. Tell students they also need to indicate the source of

Procedure

(continued)

their information and the page on which the answer appears. At the end of the class period, collect the trivia questions (make sure students' names are on their papers) and compile as many as you can for use in the game.

Session 2—Playing the Game

1. In preparation for the class, write out the questions you have selected on index cards. Write the answer and the source upside down at the bottom of the card.
2. Divide students into teams of four to six. Have students choose names for their teams and write the names on the board to keep score.
3. Determine which team goes first by thinking of a number and asking team representatives to guess the number. The team that comes closest goes first. Ask the team a question (any member may answer). If the team answers correctly, give the team one point. If it answers the question incorrectly, the question goes to the next team, and so on until all teams have had a chance to guess correctly.
4. Play now moves to team #2 whether or not team #1 answered the first question correctly. Teams continue taking their turns until one team has answered 10 questions correctly. This team is the winner.

Extension/ Evaluation

You may want to throw in some questions of your own and sponsor a trivia championship. Have students play against each other in pairs, with the winners playing other winners, working their way up a "ladder" until a wetlands champion emerges!

Some of the questions that students uncover may suggest further exploration. After the game, have each student write a short paragraph about the most interesting thing they learned about the value of wetlands.

C The Abundant Life of the Ohio River Basin

1 Flora and Fauna Along the Modern Ohio River

The Ohio River Valley contains a wide variety of flora (plants) and **fauna** (animals) that have successfully adapted to the river environment. A walk along the river's edge and its adjacent floodplain brings the sights, sounds, and smells of hundreds of species of plants and animals. The earliest spring night in the river valley is filled with the sound of spring peepers, a frog of woods and thickets near wetlands. A weekly progression of wildflowers, such as Miami mist, a blue and white delicate, fringed petaled flower of damp woods and fields, brings changing blossom and color throughout spring, summer, and autumn. Trees associated with river banks and floodplains, such as the silver maples, cottonwoods, and sycamores, line the creeks and river edges of the valley. Beech and maple forests grow on the undrained uplands. Oak and hickory tree forests dominate the well-drained hillsides.

In fall, floodplains can be abundant with the bloom and odor of the goldenrods, ironweeds, great ragweed, Jerusalem artichoke, white snakeroot, and wingstem. Plants found in floodplains and along river edges include the arrowhead, lizard's tail, cattails, and sweet-flag. True wetland habitat species, such as pimpernels, water-willow, and purple ammania can be found on river mudflats.

Also in autumn, birds converge on the oxbow wetlands. Many species of ducks, geese, birds of prey, shorebirds, and songbirds have been observed in the sand bars, mud flats, river edges, bottoms, floodplains, and wooded hillsides of the Ohio River Valley. Autumn also brings an occasional drifting osprey, also known as a "fish hawk." In late autumn, the uncommon migrating bald eagle or the even rarer golden eagle may be observed. Migratory waterfowl, which use the area for feeding and resting, include black ducks, ring-necked ducks, blue-winged teal, canvasback, redhead, pintail ducks, scaup, wood ducks, mallards, snow geese, greater white-fronted geese, and even the magnificent tundra and mute swans. Shorebirds (such as plovers, sandpipers, and yellowlegs) as well as great blue herons, green-backed herons, and egrets also use the area for rest stops during migration and for local nesting.

Other **vertebrates** that flourish here include **mammals** such as minks, muskrats, and beaver, which can be seen in and along the many streams and tributaries that feed the Ohio, as well as the surrounding marshlands. With patience, one might catch a glimpse of the rare and elusive river otter as well. The northern water snake and the garter snake are common reptiles. Almost any nonpolluted stream or pond may harbor a snapping turtle, which may grow up to 40 pounds. Another turtle, the brown softshell turtle inhabits the rivers, and the smaller painted turtle lives in a variety of wetland habitats. A large aquatic salamander called the hellbender frequents the rivers and larger streams. Despite the size and grotesque appearance of this amphibian, it is quite harmless. Ohio's smallest woodland salamander, the red-backed salamander, rarely goes into the water, but it makes its home in the floodplain. Of the many fish that inhabit the Ohio River Basin's waters, the Ohio muskelunge is the largest and most spectacular. This fish has been recorded at anywhere from 5 to 50 pounds. Other prominent species of fish include catfish, chum, white bass, and yellow fish.

2 A World in Miniature

Some of the most abundant organisms along the Ohio River are those that are difficult to see on a casual stroll. Many thousands of **invertebrates**, organisms lacking a backbone, have been found in the Ohio's 44,000 miles of streams and rivers. Thousands of these are **macroinvertebrates**, invertebrates which are small but still visible to the naked eye. The invertebrates inhabiting freshwater streams include insects, crustaceans (crayfish and relatives), mollusks (clams and mussels), gastropods (snails), oligochaetes (worms), and others. In most streams and rivers, larval insects dominate the macroinvertebrate community.

Arthropods, the group to which insects, crayfish, and spiders belong, are animals with an external skeleton, complex behaviors, and well-developed body systems. Dragonflies, beetles, and flies are a few of the insects that use watery environments to live or raise their young. Many types of crustaceans live in the ponds and streams of the Ohio River. Varieties that are easily observed with a hand lens include clam shrimps, water fleas, and fairy shrimps.

The oligochaetes or worms are composed of a number of different animals with similar shapes. Tubifex worms live on the bottom of ponds with their heads buried in the mud. Leeches are flat and segmented and found in warm dark waters. Flatworms avoid light and hide during the day, eating tiny invertebrates, dead or alive.

Hydras, which are related to the ocean-dwelling corals and jellyfish, have a single opening through which they both take in food and eliminate waste. This opening is rimmed with tentacles. They capture their food by using special cells, called nematocysts, that are found around the opening. These cells entangle, stick to, or paralyze their prey, usually one-celled animals.

Streams and rivers consist of three basic habitats. Riffles are areas of swift current, raceways are areas of moderate current, and pools are areas where water flows very slowly, if at all. In each, the temperature, oxygen content, and sediments vary. Of these three habitats, riffles and pools represent opposites. The animals that live in each of these habitats have special adaptations for their specific environment.

The swift and steady current of riffles and, to a lesser degree, raceways can dislodge and wash away small animals. For this reason, the animals that live in strong currents have flattened bodies and streamlined shapes that make them efficient swimmers. Many riffle animals, such as sponges and flatworms, also possess adaptations that enable them to resist the force of the current. Many remain on the undersurface of rocks or out of the direct line of current. They also often have special **appendages**, such as claws or suckers, for clinging to stones or to the bottom. In addition, some have developed even more specialized adaptations, such as the stonefly, whose eggs are coated with a sticky jelly that allows them to attach firmly to rocks.

In pools, animals are not threatened with being washed away. Leaves and other organic material collect in pools, providing a food source and a surface for **microscopic** plants (those invisible to the naked eye) to live and grow. Many of the animals found in pools are **predators**, meaning they depend upon other animals for their food. The lack of a current enables them to swim freely looking for prey. Other pool inhabitants are burrowers, such as mayfly or dragonfly nymphs, remaining most of the time under the protection of the bottom sediment. Because pools have less oxygen than riffles and raceways (because there is less mixing of the water), many pool dwellers have large gills and can use oxygen that has been dissolved in water or can take it directly from the air.

Two specially adapted pool dwellers are the water strider and the whirligig beetle. The strider makes use of surface tension to "skate" on the water surface. It is able to do this with the help of hairs on the tips of its legs, which are covered with a water-repellent waxy material. The whirligig beetle swims in a gyrating fashion. Because the upper surface of its body repels water, it is able to sit half in the water and half out. (See Unit II, Section B-3 for a more detailed discussion of surface tension.)

Water-dwelling macroinvertebrates generally require an environment that has a plentiful supply of oxygen and is free of toxic pollutants, although each varies in tolerance to low oxygen levels and toxic substances.

3 An Even Closer Look

Microinvertebrates are the simplest of animals, made up of only a single cell. Examples of freshwater microinvertebrates are **paramecia**, which move by means of hairlike projections called cilia, and **amoebas**, which move by means of pseudopodia, or "false feet." **Microinvertebrates**, called **zooplankton**, are abundant in ponds, lakes, and other wetlands, and are an important link in the food web. Without these life forms, the entire aquatic ecosystem could not function. Microorganisms, both plants and animals, are vital in the food supplies of fish, aquatic birds, reptiles, amphibians, and mammals—including humans.

There are tens of thousands of species of aquatic microorganisms found in many different shapes and sizes and using many different forms of locomotion. In numbers they probably exceed all other animals found in ponds and lakes. The organisms reproduce either by budding, forming an outgrowth which pinches off or breaks away from the parent cell, or by fission, simply splitting in two. These animals feed on algae, yeast, decaying materials, bacteria, or other unicellular animals. Heterotrophs obtain food from the environment, while autotrophs manufacture their own food through photosynthesis in a process similar to plants.

Phytoplankton are microscopic plants that convert the energy of the sun into chemical energy stored as food. The smallest of these plants are the **algae**, which grow where organic matter is abundant. Most algae form colorful green clumps or colonies. Diatoms, for example, are a group of yellow-green algae with finely sculptured shells.

Bacteria are another important group of microscopic organisms. Most are so small that they are not even visible through a magnifying glass or common microscope. Bacteria are seldom abundant in waters with a high oxygen content, and are therefore rare in clear ponds or lakes.

4 Birth to Adulthood: A Study in Contrasts

Many of the animals that inhabit the Ohio River look significantly different in their earliest stages of development than they do as adults. This is most obviously true for some aquatic insects. Many aquatic insects undergo metamorphosis, or changes during growth. Some insects experience simple metamorphosis, while others undergo complete metamorphosis. In simple metamorphosis, the insect egg hatches to produce a nymph. Insect nymphs have essentially all of the features of adults. As they grow, they are visibly similar at each stage.

Insects that experience complete metamorphosis are characterized by eggs that hatch into larvae. The larva grows through several stages and then changes into a pupa. Pupae are usually encased in a protective cover for their next stage of growth. From the pupae emerge the soft-bodied, often pale-colored insects. They differ remarkably in appearance from their earlier forms, but are not yet completely formed. Gradually, the soft pale body develops firmness and color. In complete metamorphosis, there is little resemblance between the adult and earlier forms.

There are also remarkable similarities and differences between other aquatic animals in different life stages. The eggs of many animals hide their eventual form (birds, turtles, fish). Aquatic mammals, on the other hand, often are easy to recognize in their juvenile forms. They frequently do not change as dramatically as some other animals in overall appearance as they grow from young to adult stages.

5 Endangered Wildlife of the Ohio River Valley

Many of the plants and animals that inhabit the rivers, streams, and wetlands of the Ohio River basin are now extremely rare. Plants and animals that are so rare that they are in danger of becoming extinct are known as endangered species. Wildlife whose numbers are very low or are rapidly decreasing are called threatened. They are not endangered yet, but could become endangered if the threats they face are not alleviated.

The Endangered Species Act of 1973 charges the U.S. Department of the Interior with identifying species that are in immediate danger of extinction. Such species are officially designated as endangered and receive protection under the Act. The Act further requires the mapping of endangered species habitats and forbids any private, state, or federal agency to destroy such habitats in the course of construction projects such as dams, highways, or airports. Recovery plans for all endangered species have also been developed by the U.S. Fish and Wildlife Service. A critical element of these plans is habitat protection. The wetlands and floodplains of the Ohio River need to be viewed as important wildlife habitats when planning for future use.

Resources

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Weishaupt, C.G. 1971. Vascular Plants of Ohio. A Manual for Use in Field and Laboratory, 3rd ed. Dubuque, IA: Kendall/Hunt Publishing Company.

Western Regional Environmental Education Council. 1987. Aquatic Project Wild: Aquatic Education Activity Guide. For more information, contact Western Regional Environmental Education Council, P.O. Box 18060, Boulder, CO 80308-8060, 303-444-2390.

Audiovisual Programs

Amphibians: Frogs, Toads, and Salamanders. Phoenix Films, Inc. (BFA Educational Media), 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. With close-up and micro photography, this film illustrates a typical amphibian life cycle and studies the differences between three kinds of amphibians (11 minutes). Intermediate to senior high levels.

The Ecosystem: Network of Life. Phoenix Films, Inc. (BFA Educational Media), 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. This film explores the interactions that take place between living things and between organisms and the physical elements in their environment (11 minutes). Junior to senior high levels.

Freshwater Biology. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Describes a freshwater environment with examples of food chains (slide show). Cost: $37.95.

Freshwater and Saltwater Marshes. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Describes and illustrates the various types of marshes, how marshes are formed, and the plants and animals common to these wetland habitats (video or slide show).

Resources *(continued)*

Frogs: An Investigation. Phoenix Films, Inc. (BFA Educational Media), 468 Park Avenue South, New York, NY 10016, 1-800-221-1274.

Vanishing Animals of North America. National Geographic Society, Educational Services, Dept. 85, Washington, DC 20036. Filmstrip with cassette. Advanced grade levels.

Water and Plant Life. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NY 08540, 1-800-257-5126. Covers the water cycle and plant life (28 minutes). Rental: $75.

What Is a Fish? Encyclopaedia Britannica Educational Corporation, 310 S. Michigan Avenue, Chicago, IL 60604, 1-800-554-9862. Focuses on the main types of modern bony fishes, showing their behaviors and morphologies. Includes a time-series of a developing fish embryo (20 minutes). Senior high.

The World of a River. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Illustrates aspects of a river system and the characteristics of the animals and plants found therein (slide show). Cost: $79.95.

C

Activity

Water Plant Art

Objective

Students will learn to identify a variety of plant life in aquatic environments by collecting, mounting, and writing about them.

Setting

Indoors, and outdoors if students assist in gathering plant material

Duration

One 20- to 40-minute period (an additional period for collecting)

Subject

Art, Biology, Science

Skills

Analysis, Classification, Comparing Similarities and Differences, Discussion, Media Construction, Psychomotor Skills

Grade Level

K-12 (Younger children will need assistance with identification and may not perform the written part of the activity.)

Vocabulary

algae phytoplankton

Background Information

Refer to Unit I, Section C-1. (Also see Unit I, Section B-1.)

Materials

- Samples of aquatic plants that have been collected.
- Shallow pan filled with fresh water.
- Heavy, porous white paper and wax paper.
- Newspapers.
- Several large heavy books or a plant press.
- Waterproof marking pen.
- A reference guide to common aquatic plants (see Resources for Unit I, Section C).

Procedure

1. Talk with students about the importance of there being a variety of plant life in aquatic habitats. (Plants are important parts of aquatic ecosystems, providing food and shelter for aquatic animals.)
2. Show the students pictures of some different kinds of aquatic plants, animals, and habitats such as lakes, streams, and marshes. (A slide show or film might be ideal for this purpose.)

Procedure *(continued)*

3. Show the students a sampling of the aquatic plants you have collected. If you collect these yourself, do not take a large amount from any one area, or, if possible, from any single plant. Also, ensure that none of the plants you are collecting are protected by law. Make sure the plants are abundant and that you will do no permanent damage to the surrounding environment by removing them. While gathering these plants, also look carefully for aquatic animals. Gently remove any that you find rather than accidentally taking them with your sample. Put samples in plastic bags to keep them moist.

Note: If you collect plants with students as a field trip, discuss "field ethics" before you go. Follow the rules for not damaging animals, plants, and habitat detailed in Step 3. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!")

4. Ask the students to identify the different types of grasses, algae, or other aquatic plants you collected. You may need to use reference materials or find plant experts on the faculty or in your community to help you do this.
5. Place the plants in a pan filled with water. Clean them and, if you want, tear the plants into smaller sizes for mounting.
6. Have individual students or small groups select plants from the pan, gently lifting them and placing them on heavy, porous paper. Have each student or group arrange the plants or parts of plants into a desired design.
7. Cover the arrangement of plants with wax paper.
8. Have students identify the plant and write its name on the wax paper with a waterproof pen, along with where and when it was found.
9. Lift the artwork, white paper, and wax paper, and place it between several sheets of newspaper. (The wax paper protects the plant, while the water will seep through the white paper. As the plant dries, it will adhere to the paper.)
10. Place the stack of newspapers containing the plant on a flat surface. Stack several heavy books on top to serve as a plant press. An actual plant press is ideal, if available.
11. Drying may take from a few days to several weeks depending on humidity.

Procedure *(continued)*

12. Display the aquatic art and ask the students to talk about what they learned. Again talk with students about the importance of the variety of plants in aquatic environments. Ask students to give examples of ways these plants are important.

These plant prints can serve many purposes, including plant identification keys for classroom use and for bulletin board displays. The wax paper can be retained as protection, or it can be removed gently, leaving the plant dried to the paper.

Extension/ Evaluation

Use the dried plants to make a "field guide" of the pond or stream where the plants were found. Students can research and write short informational paragraphs about the plants they have preserved to accompany the artwork. You might want to have students design a cover and develop an introduction for the book that describes the habitat where the plants were found and discusses how these plants provide food and protection for animals that live in or near the water.

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C

Activity

Life Stages

Objective

Students will learn to recognize young stages of aquatic animals that may look dramatically different from their corresponding adult stages.

Setting

Classroom

Duration

One 20- to 40-minute period

Subject

Science

Skills

Analysis, Classification, Comparing Similarities and Differences, Recognition, Small Group Work

Grade Level

3-6

Vocabulary

metamorphosis nymph larva pupa

Background Information

Refer to Unit I, Section C-4 and Section C, Resources.

Materials

- Pairs of aquatic animal cards (you can either use the ones on the Life Stages Clip Art pages following or design your own).
- Pens and/or markers for designing cards.

Procedure

1. Make pairs of aquatic animal cards. The animals in the pair should be the same kind. For example, one might be a pair of beavers; another might be a pair of ducks. One animal in the pair should be an adult, while the other should be at a younger stage of development. The pairs might include adult, larval, nymph, hatchling, juvenile, infant, and/or egg forms. Use the master provided, if you like.
2. Ask the children to bring two pictures from home, both of the same person. One should be of that person as an adult; the other as a child. The students could also bring in pictures of themselves as infants and at a recent age.
3. Divide the class into small groups of three or four students each. Have them hold their own set of paired pictures in their hands. Assign each group a single table or station. Ask them to stand in a circle around that station.

Procedure

(continued)

4. Have the students at each station place their pairs of pictures on the table and mix them randomly. Once the adult-child pictures are mixed at each table, have the entire group shift to another table, so there will not be anyone at the tables where their own pictures are placed.
5. At the new table, have the group attempt to match pairs of adult/child or student and infant photos.
6. When the students at each table have completed their efforts to match the pairs, ask all of the groups to return to their original tables—the place they left their own pairs of pictures. Are the matches correct? Ask the students to change any pairs that are not correctly matched. Talk about how difficult or easy it was to correctly match the pairs. Introduce the idea that many animals that are familiar to them look remarkably different as adults than they appeared in their younger forms. Tell the students that they are about to learn how to match young and adult forms of different kinds of aquatic animals that they might find in ponds, lakes, and rivers nearby.
7. Introduce the aquatic animal cards and divide the class in two. Designate one half of the students "adults" and the other half "young animals." Distribute one card to each student, making sure there is a corresponding match, adult or juvenile, for each card given. Instruct the students to look for their "match"—pairing the adult and juvenile forms.

Note: You can attach each animal card to a string loop so the pictures can be hung around the students' necks as they try to match the pictures.

8. When all the students have made their choices and think they have a match, let everyone help to see if the matches are correct. Some are more difficult than others and may be confusing, especially for younger children. You may need to show the students the matched images on the master.
9. Have all of the students look at all of the correctly matched pairs. Look at similarities and differences in how different kinds of aquatic animals grow and change.

Note: This activity can be repeated several times by shuffling the adult and young images and passing them to new "animals" so that each student becomes familiar with a wider array of animals.

Extension/ Evaluation

Have students each pick one pair of images and find out more about the life cycles of the animals shown. Have them present what they have learned to the class, either through a series of pictures or by pantomiming the metamorphoses of their animal. If possible, you may want to take a field trip to a habitat where some of these animals live and find some of them in the wild.

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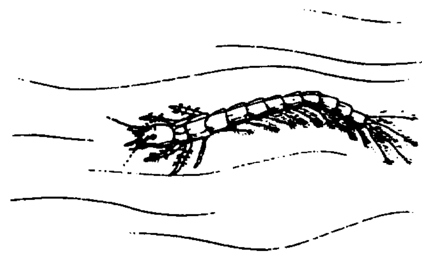
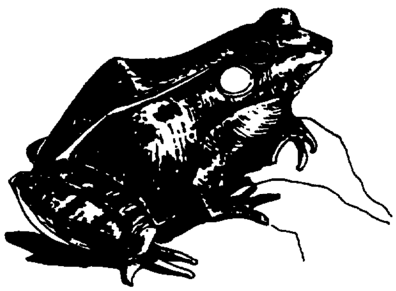
Life Stages Clip Art

Whirligig Beetle

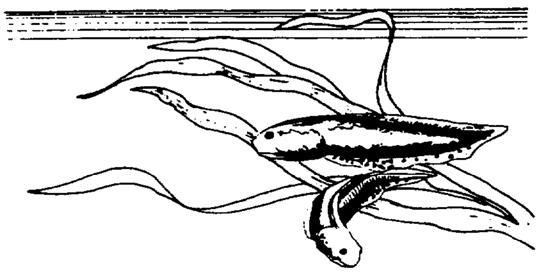
Whirligig Larva



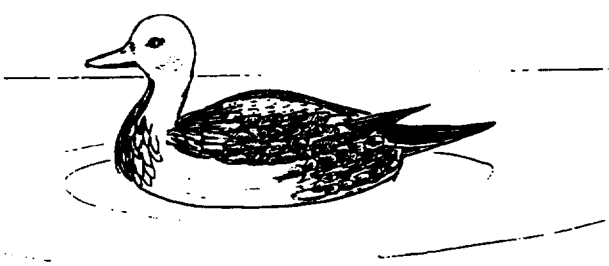
Frog



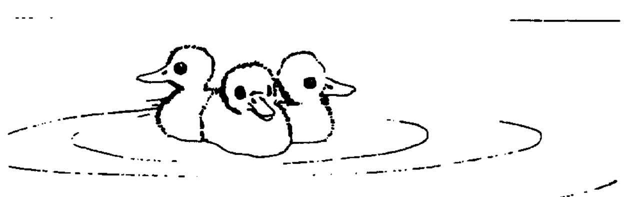
Tadpoles



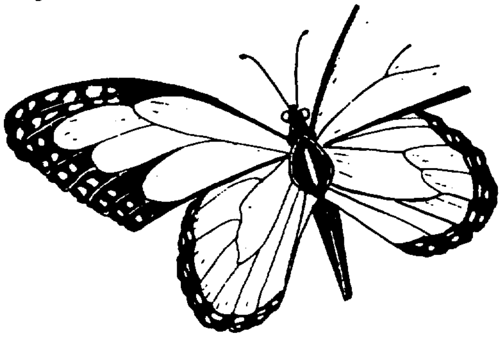
Duck



Ducklings



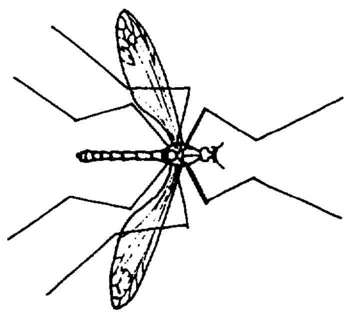
Butterfly



Butterfly Larvae

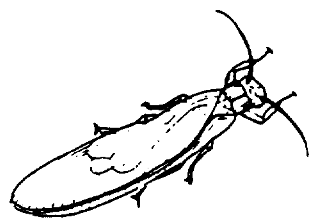
Life Stages Clip Art

Cranefly

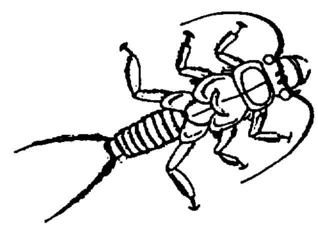


Cranefly Larva

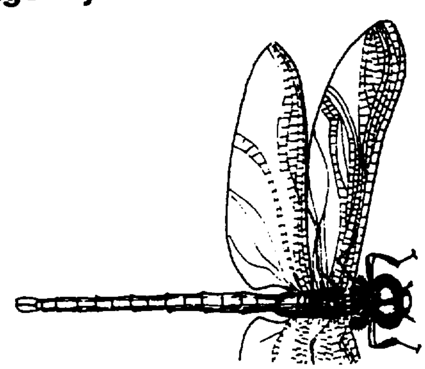
Stonefly



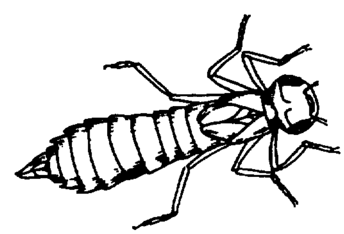
Stonefly Nymph



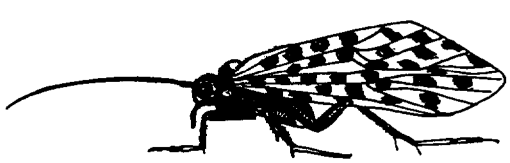
Dragonfly



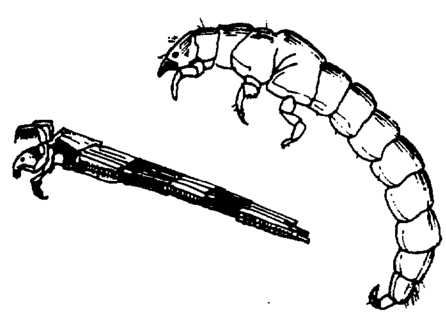
Dragonfly Nymph



Caddisfly



Caddisfly Larvae

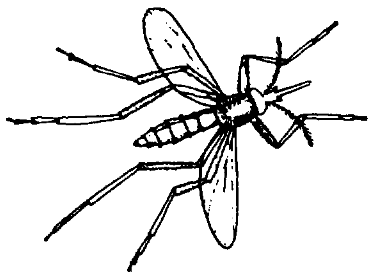


Life Stages Clip Art

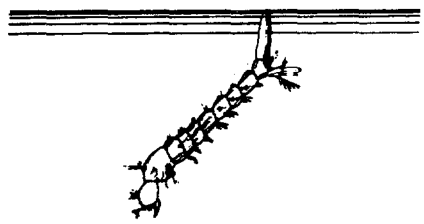
Adult Beaver

Young Beavers

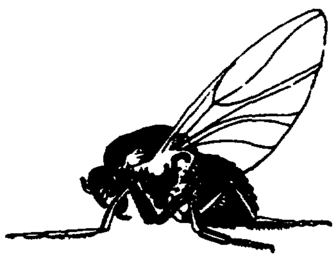
Mosquito



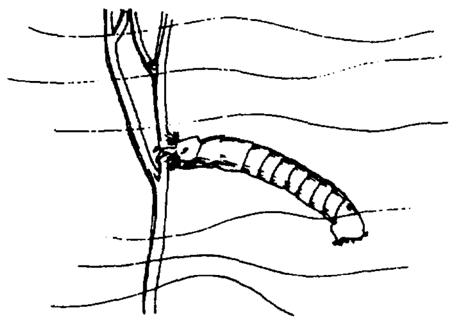
Mosquito Larva



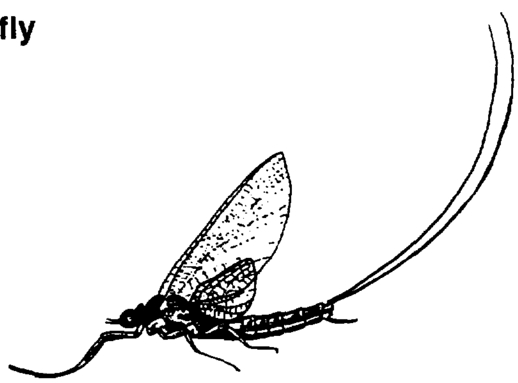
Black Fly



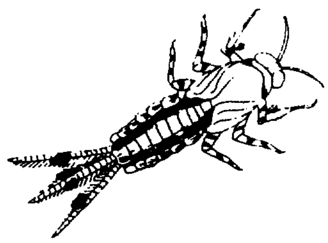
Black Fly Larva



Mayfly



Mayfly Nymph



C

Activity

Field Observations of Aquatic Organisms

Objective

Students will collect aquatic microorganisms and learn about their habits and life history through observation.

Setting

Outdoors at a pond or slow-moving stream, and in the classroom

Duration

Three 45-minute periods

Subject

Art, Biology, English, Language Arts, Science

Skills

Collecting, Observation, Identification, Writing, Drawing

Grade Level

4-12

Vocabulary

microinvertebrate macroinvertebrate microscopic amoeba paramecium cilia zooplankton appendage predator

Background Information

Refer to Unit I, Sections C-2 and C-3, and Unit I, Section B-1.

Materials

- Pond water.
- Hand lenses.
- Magnifying glasses.
- Fine mesh nets.
- Microscopes.
- Writing materials.
- Poster paper.
- Mural paper.
- Paints.
- Tape.
- Handout of Aquatic Microorganisms.
- Field and reference guides (see Resources for Section C).

Procedure

1. Collect samples of water from a pond or stream that contain microorganisms. One or two gallons should be adequate; however, you may want to collect enough to stock a small aquarium. If you choose to use an aquarium, collect the bottom material with soil and detritus as well. Aquatic plants should also be transplanted into the aquarium, and certain aquatic insects such as diving beetles and water striders may be included.

Note: See Appendix A, "Keeping Classroom Aquaria—A Simple Guide for the Teacher," for additional information. This phase can either be done as a field trip with the students or in advance by the teacher. If it is done as a field trip, discuss with students the concept of "field ethics" before you go. Encourage students to collect only organisms that are in relative abundance and not to collect anything that they do not think they can keep alive in captivity. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!")

2. Invite students to remove about a tablespoon of the water from the container. Remember to tell them to get the water from deeper in the container and not just at the surface. Have them examine the water with hand lenses and microscopes. Tell them to make sketches of living things they find. They should note how the organisms move and how they interact. Do some seem to be predators? Which forms of life do the predators prey on?

3. After they have sketched several organisms, encourage them to choose a favorite life form to make a large painting of. Students should strive for detail and accuracy in portraying the organism. However, encourage artistic license and the use of color in the background and the area surrounding the life form. Also, ask them to write a short paragraph about their observations of the organism, answering such questions as:

   - Where was it found?
   - How does it move?
   - How big is it?
   - What does it eat?

4. Have students try to identify the organism they painted. Some common pond organisms are shown on the following pages. Because there may be microorganisms that are difficult to identify, you may have the students give their organism a temporary name until they can find an adequate reference.

Procedure *(continued)*

5. Create a class mural of the pond or stream and its aquatic organisms. Display the written paragraphs near the corresponding organisms. Arrange them to show their relationship to one another.

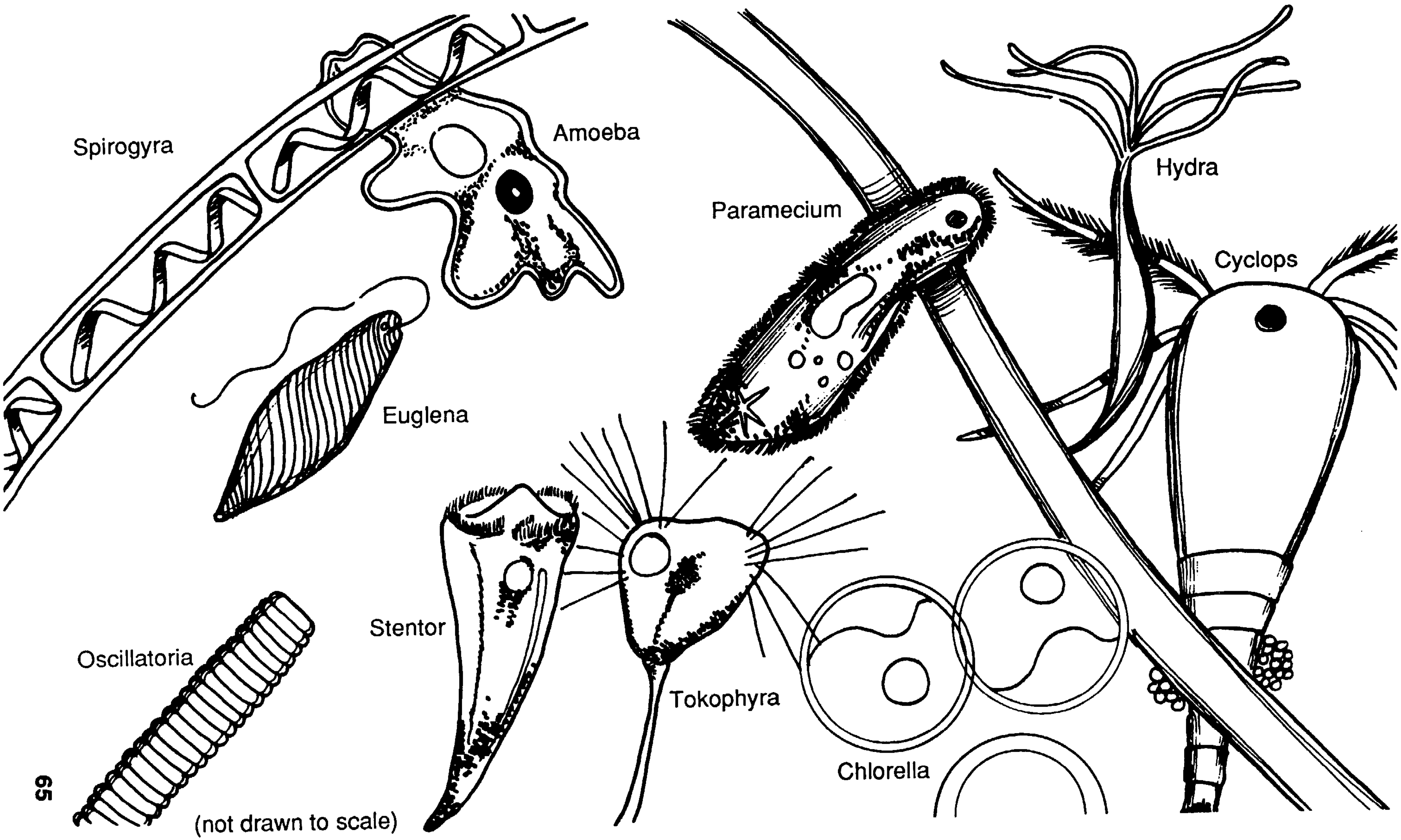
At the end of the activity, return the water to its source, if possible.

Extension/ Evaluation

Encourage students to do some additional research to discover more about the organism they chose to draw and write about. After students have had a chance to study the projects done by other students, have them draw a food web containing at least one producer, one consumer, and one decomposer. They should be able to accurately draw and label the corresponding organisms.

Adapted with permission from: Western Regional Environmental Education Council, Aquatic Project Wild (Boulder, CO: WREEC, ©1987).

Aquatic Microorganisms



C

Activity

Wildlife Flash Cards

Objective

Students will learn to recognize some familiar vertebrate species that inhabit the Ohio River Basin.

Setting

Indoors

Duration

One 30-minute period

Subject

Biology, Science

Skills

Memorization, Identification, Recognition

Grade Level

3-8

Vocabulary

vertebrate amphibian reptile

Background Information

Refer to Unit I, Section C-1.

Materials

Create flash cards (approximately 3 x 5 inches) of common vertebrates associated with the Ohio River Valley by drawing, photocopying, or cutting out illustrations from magazines or field guides. Cards should include birds, mammals, reptiles, amphibians, and fish. You may want to use one set of cards for the entire class or reproduce the pages to make sets so that students can work in small groups or pairs.

Procedure

You may want to initiate this activity by allowing some time for browsing or free reading in field guides and other reference materials.

1. Divide students into two teams. Let the teams choose names for themselves and write their names on the board so you can keep score.
2. Go through the flash cards once as a practice round, holding up each card individually and allowing time for a student from either team to name the animal. If he or she only names it partially (for example, "duck" instead of "pintail duck" or "frog" instead of "leopard frog"), give other students a chance to answer. If no one can "name that animal," tell them the answer and go on to the next card.

Procedure

(continued)

3. Now you are ready for the real game. Have both teams count off so that each person has a designated number. Tell students that if it is their turn and they know the answer, they must raise their hand as soon as possible. You will call on whoever raises his or her hand first. (Remind them that if they answer incorrectly, they can lose a point, so they should only raise their hand if they have a good guess.) Begin by holding up the first flash card to the player #1s on both teams. Allow the first player with a hand raised to answer. If he or she answers correctly, that team gets a point. If he or she answers incorrectly, the team loses a point, and the other player #1 gets a chance to answer. If neither answers correctly, the card goes back into the deck. (If the card is guessed, put it aside.)
4. Proceed with play by holding up the next card for the #2 players. Play until all of the cards have been guessed.
5. If any cards are left over, talk to students about distinguishing marks and how they might be able to remember the animal the next time.

This game can be played again later after students have spent more time studying wetland wildlife. They might enjoy seeing how much they have learned. The game can also be played in pairs with students taking turns showing each other cards from a face down deck and keeping track of how many points each person earns.

Extension/ Evaluation

Take a field trip to a nearby pond, marsh, or river side park or wildlife refuge, preferably in early morning. Bring binoculars and see how many of the species on the flash cards you can identify in the wild. If you like, note animals that you see that are not on the flash cards. Back in the classroom, give students a chance to expand their deck of flash cards with drawings of these animals.

C

Activity

Plaster Casts of Animal Tracks

Objective

Students will identify and preserve animal tracks found on or near a riverbank, streamside, or pond, and make inferences concerning the animals' activity.

Setting

Outdoors

Duration

One 2-hour period

Subject

Art, Biology, Science

Skills

Observation, Collection, Identification, Media Construction

Grade Level

5-12

Vocabulary

mammal

Background Information

Refer to Unit I, Section C-1.

Materials

- Plaster of Paris.
- Plastic container.
- Stirrer.
- Animal Tracks handout.
- Cardboard.

Procedure

1. Arrange a field trip to a "collecting" site on the banks of a river, stream, or pond. Before the trip, discuss with students the kinds of signs you might find there. Explain to them that although they will not see many mammals moving around during the day, they will often be able to find their tracks in the mud beside rivers, lakes, streams, and ponds.
2. At the site, spend some time getting acquainted with the area and finding places where tracks are the clearest and easiest to identify. Pass out the animal track handout to give students an idea of what they might find.
3. Have students work in pairs to locate a good, clean animal track and make a permanent cast. (You may want to do one first as an example.) To make a plaster cast, follow these steps:

Procedure *(continued)*

- Cut a piece of cardboard into a strip at least 20 inches long by 2 inches deep, and bend it into a circle by sticking one end over the other. Gently push the ring into the ground around the footprint.
- Make a thick, runny paste of plaster of Paris by adding the powder to a plastic container half filled with water.
- Carefully pour the mixture into the ring to a depth of about 1 inch. Leave it for 20 minutes to set.
- When the plaster has dried, remove the outer ring and turn the cast over to see the raised impression of the footprint.
- Leave the cast overnight before washing away any mud with water.

4. While you are waiting for the casts to set, discuss the different types of tracks that were seen and identify as many as you can. Try to guess how long ago and in which order animals visited the area.

Note: Caution students to be careful not to inhale plaster of Paris dust while mixing paste. Or mix plaster of Paris yourself before students are ready to begin making their casts.

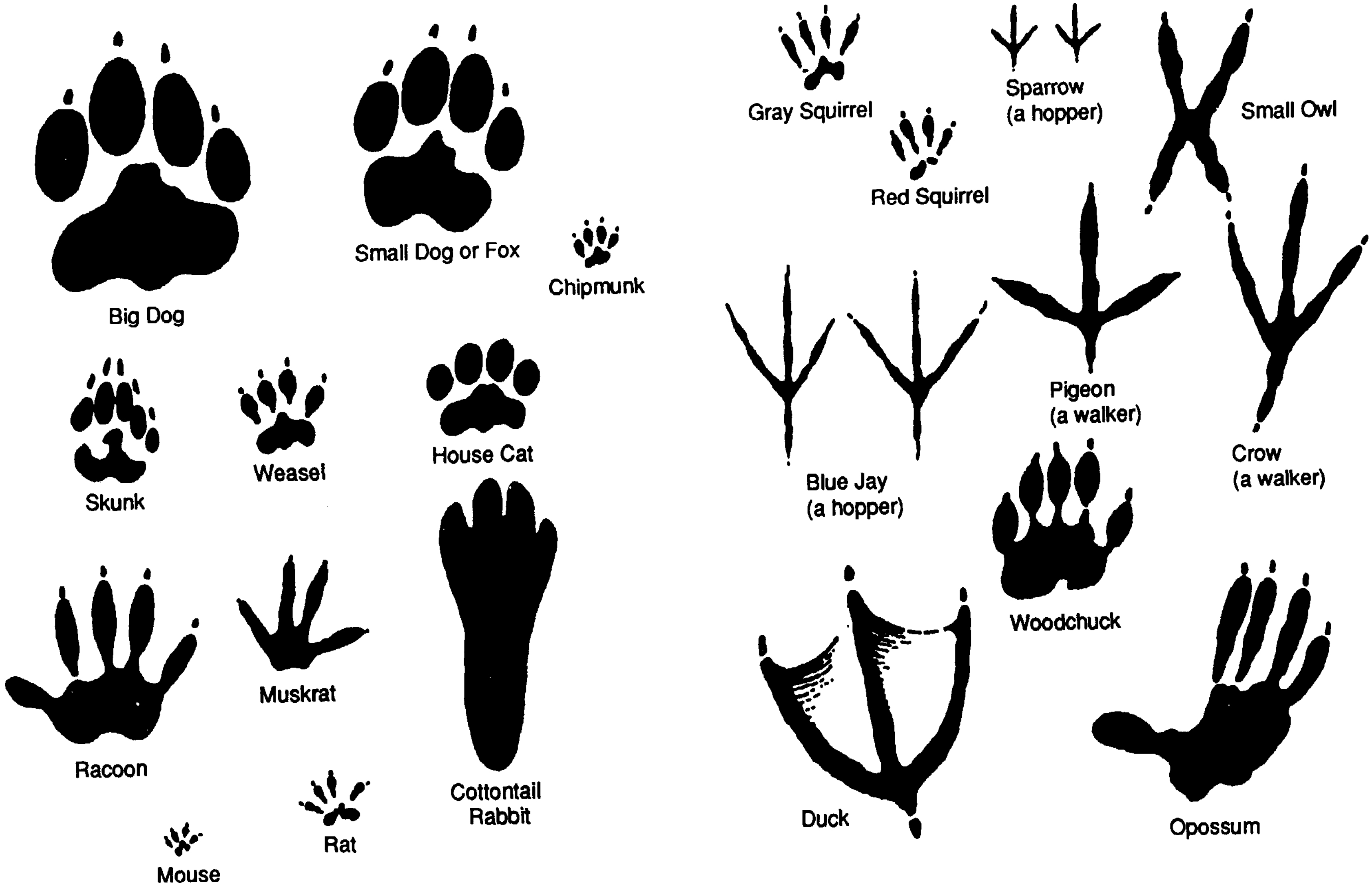
Extension/ Evaluation

You might like to conclude the activity with a discussion of other types of animal signs students saw or might see. Some examples might be a muskrat house, a beaver dam or gnawed branches, bark stripped off a tree by deer, or an animal burrow dug in a river bank.

To make the animal tracks stand out against the white plaster, students may wish to paint them in different colors. Encourage students to perform further research on the animals whose tracks they have cast and prepare a "fact sheet" including this information and a picture of the animal. Make a display in the classroom of the tracks and their corresponding fact sheets.

Animal Tracks

Circle all the animal tracks on this page that you have observed in the field



C

Activity

Wetlands Safari

Objective

Students will make a survey of animals and plants sighted on a wetland field trip and discuss populations based on their observations.

Setting

Outdoors at a wetlands park or refuge (Teachers should determine wetland location in their area prior to the trip.)

Duration

A morning or afternoon

Subject

Mathematics, Science

Skills

Observation, Classification, Recording Data, Identification, Comparing Similarities and Differences, Inference, Synthesis, Computation

Grade Level

K-12 (The students' ability to identify species independently will vary with the age level. Younger students will need more guidance from the teacher.)

Vocabulary

flora fauna food chain vertebrate invertebrate
mammal reptile amphibian

Background Information

Refer to Unit I, Sections C-1 and C-2. (Also see Unit I, Sections B-1 through B-7.)

Materials

- Copies of Wetlands Survey handout.
- Field guides to insects, birds, mammals, plants, fishes, reptiles, amphibians, and freshwater wildlife (see Unit I, Section C, Resources).

Procedure

Note: This might be a good activity to undertake after students have performed some of the other activities in this section that would help with identification.

1. Tell students to imagine that they are wildlife researchers hired to find out what kinds of plant and animal species are living in the area you'll be surveying. Discuss some of the questions they are being hired to answer.
   - What are the dominant plant species?
   - What are some of the other kinds of plants growing in the ecosystem?
   - What kinds of creatures live in the soil?
   - What kinds of invertebrates are living in the water?

Procedure *(continued)*

- What vertebrate species (mammals, birds, reptiles, amphibians, fishes) live in the area?
- What is the total number of each species identified?

2. Pass out the survey chart. Explain to students that they will keep a record of everything they have sighted by writing down the name and number seen to the best of their ability. (Tell them that they will need to use their field guides and may ask you for help if they get stuck.) Have them concentrate on identifying the things they can see and distinguish easily, and have them include signs of animals even if they do not see the animal itself. (For example, if they see a beaver dam or lodge, they should write that down under mammals.)

3. After students have had about an hour to make their observations, bring them back together to discuss their findings. You might begin by asking some of the questions raised above. You might also ask some of the following questions:

   - In which category did you find the most different species? (insect, mammal, bird, fish, reptile, amphibian, other)
   - What category of animal was next most common?
   - In which category did you find the least animals? (They will probably say "mammals.")
   - Can you guess why? (This might be a good place to introduce the idea of a food chain or pyramid with fewer animals at the top. Other answers might be: many are nocturnal, they are more frightened of humans, they need more space.)
   - If you went back to this area at a different time of day, how might your list change? Why?
   - How about at a different time of year? Why?

Extension/ Evaluation

Plan a second trip to the same location at a different time of day or a different season. Before you go, discuss possible changes that students might observe in the numbers and kinds of wildlife. If your wetland area is on a migratory flyway or is a wintering ground for bird species, try to go when bird populations will be at their peak. After the trip, discuss whether your predictions were correct.

Based on all of the surveys, develop a wildlife checklist like the kind that is available at most national wildlife refuges. The checklist should contain all species that have been seen in the area; whether each species is abundant, common, uncommon, or rare; and in which season(s) the different species can be observed.

Wetlands Survey

Location: ______________________ Date: __________ Time: ___________

Plants		Insects	Other Invertebrates
Fish	**Reptiles and Amphibians**	**Birds**	**Mammals**

C

Activity

Endangered Species Poster

Objective

Students will explore ways to ensure the survival of endangered species in the Ohio River Basin by designing a poster that encourages the protection of an endangered species.

Setting

Classroom

Duration

Two or three 1/2 hour class periods

Subject

Art, Language Arts, Science, Social Studies

Skills

Painting or Drawing, Writing, Researching, Media Construction, Communication

Grade Level

K-6 (7-12 using suggested Extension activity)

Vocabulary

endangered threatened extinct

Background Information

Refer to Unit I, Section C-5.

Materials

Materials:

- Large pieces of sturdy paper or oak tag for poster-making.
- Poster or acrylic paints, colored markers.
- Reference books on endangered animal species or a library where students can perform research.

Procedure

Present children with background information about endangered and threatened species, particularly in the Ohio River Basin. Explain to them that one way to help endangered plants and animals is through education, and this is something they can do right in their own classroom.

1. Have each student choose an endangered plant or animal that he or she would like to protect. You might like to post a list of endangered species in the Ohio River Basin to give students ideas.
2. Allow at least one class period for students to research their plant or animal. Tell them that their poster should not only be attractive and have a message, but should also teach something about the species. Some things they might want to include are:

Procedure *(continued)*

- Where the species lives.
- What the species eats.
- How many there are left.
- What threatens the species.
- How the species is being helped.

3. Provide students with the art materials they will need to design and complete the poster. You may want to have students complete a draft on plain white paper first, which you can discuss with them before they do the final poster. Allow at least one class period for students to make the finished poster.
4. Display the posters in your classroom or on a school bulletin board.

Extension/ Evaluation

You may wish to hold a poster contest, where entries are judged on such criteria as effectiveness of message, educational value, and/or artistic execution. The contest could be titled "Save Our Species" and could be judged either by other faculty members or another class doing the same project.

If equipment is available, older students (7-12) may wish to work in groups to develop a videotaped public service announcement that encourages the protection of a particular endangered species or a wildlife area where an endangered species lives.

UNIT II

Physical, Chemical, and Biological Aspects of Water

Physical, Chemical, and Biological Aspects of Water

This unit focuses on the unique properties of water and emphasizes the importance of water to all living things. Activities in *Section A* illustrate that without water, there would be no life on Earth. Activities also focus on the world's water supply and on the water cycle, which constantly "recycles" the Earth's water supply from one form to another (solid, liquid, vapor).

Activities in *Section B* focus on various physical and chemical properties of water, including temperature, velocity, solubility, density, surface tension, pH, and nutrient content. At the close of this section is a field activity in which students determine the relative amount of pollution in a water body by analyzing water samples and discerning the types of invertebrate "indicator" species present. This activity provides an opportunity for students to apply the knowledge they've gained from other activities in Section B, as well as from Unit I, and serves as an introduction to Unit III, Human Use, Influence, and Impact on the Ohio River.

A Earth: The Water World

1 A Planetary Perspective

Water covers three-fourths of the surface of the Earth, and every land mass on the planet contains some water. In addition to the oceans, water is found on Earth in rivers, streams, lakes, ponds, pools, estuaries, and wetlands. Water is also found under the ground and in the atmosphere.

Earth has more water on its surface and in its atmosphere than any other planet. In addition, Earth is the only known planet where water is found in all three states of matter: gas (vapor), liquid (water bodies), and solid (ice). Water on Earth can also move freely from one state to another.

In contrast, Mercury, the closest planet to the Sun, has no water at all. Clouds cover Venus, but they are made of dust and droplets of sulfuric acid, not water. There isn't enough water on Venus to fill a single ocean on Earth. The water on Mars exists as subsurface permafrost and as polar ice caps hundreds of feet thick. The Martian atmosphere contains only a trace of water vapor. Both Venus and Mars have lost most of their water to solar ultraviolet radiation.

On Earth, very little water vapor rises high enough in the atmosphere to be exposed to solar ultraviolet radiation. In addition, Earth is protected by a layer of atmospheric oxygen (ozone), which absorbs incoming ultraviolet waves. Very little ultraviolet radiation passes through the ozone layer to reach the abundant water vapor close to the Earth's surface.

The planets beyond Mars (Jupiter, Saturn, Uranus, and Neptune) are composed mainly of hydrogen, helium, ammonia, and methane. Jupiter has some water droplets and ice in a lower cloud layer. Saturn, Uranus, and Neptune are too cold for water to exist in any form but ice. Pluto's composition is unknown, but would not likely include any liquid water.

2 The Water Cycle

There is the same amount of water on Earth today as there was millions of years ago during the time of the dinosaurs. Although the amount of water on Earth doesn't change, water is constantly moving and changing its form. This movement has a regular pattern to it and is called the **water cycle**. As the word "cycle" implies, the events repeat themselves over and over again. See Figure IIA-1.

The water cycle collects, purifies, and distributes the Earth's fixed supply of water. With energy supplied from the sun, water is **evaporated** from oceans, lakes, rivers, streams, and ponds. In addition, animals and plants also give off water vapor (**transpiration**), particularly green plants which constantly lose water from their leaves to the atmosphere. In the atmosphere, this water vapor rises with warm air until the air begins to expand and cool as it reaches higher altitudes. Since cold air cannot hold as much moisture as warm air, the water vapor condenses into tiny droplets of water in the form of clouds or fog in a process known as **condensation**. Eventually, these droplets grow larger and heavier and fall to the Earth as **precipitation**.

Much of the precipitation that falls to Earth becomes locked in glaciers and icecaps. Some precipitation also collects in puddles and ditches and is carried as **runoff** into nearby **surface water**, such as lakes, rivers, and streams, which eventually return this water to the ocean. Precipitation also seeps or infiltrates into the soil. Some of this precipitation continues to percolate down deep into the ground where it is stored as **ground water** in aquifers (spaces in and between rock formations). In aquifers, ground water continues to move horizontally underground following the contours of the surrounding rock layers until it eventually returns to the surface and to rivers, lakes, streams, or the ocean. (See Section IIIB-2 for more information on ground water.)

3 The World's Water Supply

The world's supply of water is enormous. It has been estimated at over 369 quintillion gallons (369,820,250,000,000,000,000 gallons). However, over 97 percent of Earth's water is found in oceans as saltwater, and contains too much salt for drinking, growing crops, or most industrial uses.

The remaining 3 percent of the Earth's water supply is **freshwater**. Most of this (about 2 percent) is locked up in glaciers and ice caps, mainly at the North and South Poles. If the polar ice caps were to melt, the sea level would rise and inundate much of the present land surfaces in the world. The rest of the world's supply of freshwater (less than 1 percent) is found in water bodies such as rivers, streams, lakes, and ponds; in the atmosphere; and underground.

The amount of water contained in rivers and lakes is very small compared to the total amount of water found on Earth. Lakes account for approximately 0.009 percent of the total water supply, and rivers account for only about 0.0001 percent of Earth's total water supply. Although small, this portion is important to people, who use this water for drinking water and other purposes, and to the organisms that live in it.

Water is also found in the swirling clouds that cover Earth. All the water in the atmosphere makes up only 0.0001 percent of the planet's total. If it were all to fall evenly over the Earth as rain, it would make a layer about 1 inch deep.

In addition, water is found underground. Ground water makes up about 0.62 percent of the Earth's water supply. While scientists believe there are vast amounts of usable ground water on Earth, this water is not always readily available for human use because it must first be located and then extracted.

4 Water: A Necessity for Survival

Without water, no life could exist on the Earth. All life on the planet is composed largely of water and depends on water for its survival. Water flows in our veins and in the sap of trees, as well as in our streams and rivers. The adult human body is composed of 65 to 75 percent water. In order for humans to survive, they must drink liquids or eat food containing at least 1.5 quarts of water every day (large animals like horses need about 15 gallons of water a day). People, as well as plants and animals, can live only a few days without water.

Plants also need water for **photosynthesis**, a process that occurs in the cells of plants that provides energy (in the form of glucose) for the plants' growth. (See Unit I, Section B-1.) In general, plants obtain water from the soil through their roots. Most animals, on the other hand, acquire water by drinking from pools, lakes, or streams; by consuming foods high in water content (such as fruits and vegetables); or by the process of cellular respiration, the process by which oxygen is used to release the energy stored in cells. Water and energy are released through respiration.

Without water, Earth's surface temperatures would be too hot at the equator and too cold at the poles for living organisms. The oceans buffer the Earth from extremes in temperature by absorbing, storing, and redistributing heat from the sun. In this way, the oceans moderate and regulate climate all over the world, thereby enabling life forms to exist.

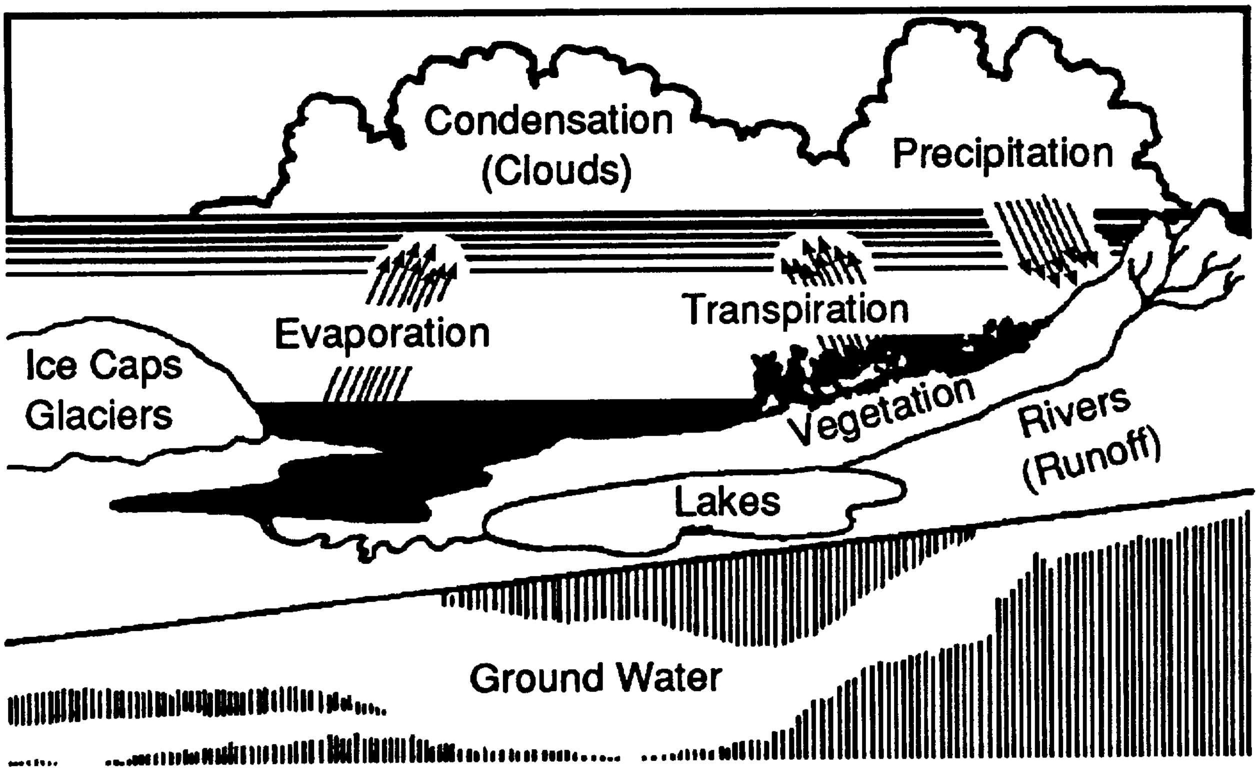


Figure IIA-I. The main processes in the water cycle are evaporation (conversion of liquid water to water vapor), transpiration (the process in which water is absorbed by the root systems of plants, passes through their living structure, then evaporates into the atmosphere), and condensation (conversion of water vapor to liquid drops of water). After water vapor condenses in the atmosphere, it returns to Earth as precipitation (dew, rain, sleet, hail, snow) and either infiltrates the soil and becomes ground water or is carried as runoff back to the sea to begin the cycle again.

Resources

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Resources *(continued)*

Audiovisual Programs

Down the Drain. 1991. Children's Television Workshop. (30 minutes.) Call the U.S. EPA at 513-569-7771 for ordering information.

Element 3. International Film Bureau, 332 South Michigan Avenue, Chicago, IL 60604-4382, 312-427-4545. A look at the contrast between the lyrical beauty of pure water and the aridity of its absence; focuses on the cooperation that is essential for the distribution of water. Video or 16mm film.

H_2O TV: The Groundwater Video. 1989. Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-194. (Approximately 10 minutes.) Call the U.S. EPA at 513-569-7771 for ordering information.

Learning About Air and Water. National Geographic Society, Educational Services, Department 91, Washington, DC 20036, 1-800-368-2728. Covers the basics about air and water, including interactions in the water cycle, as well as causes of pollution (19 minutes). Grades 4-9. Film or video. Rental: $25.

The Surface Water Video. 1989. Water Pollution Control Federation, 601 Wythe Street, Alexandria, VA 22314-194. (Approximately 10 minutes.) Call the U.S. EPA at 513-569-7771 for ordering information.

The Water Cycle. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. A comprehensive overview of the hydrologic cycle. Slide show. Cost: $37.95.

Water: A First Film. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. Describes the importance of water to plants, animals, and the Earth (12 minutes). Primary and intermediate grade levels. Video or 16mm film.

Water and Life: A Delicate Balance. #IE-1139. Films for the Humanities & Sciences, 743 Alexander Road, P.O, Box 2053, Princeton, NJ 08540, 1-800-257-5126. Shows the role of water in the human body (13 minutes). VHS or Betamax videocassettes; 3/4" U-matic copies also available. Rental: $75.

Resources *(continued)*

Water and Plant Life. #IE-1674. Films for the Humanities & Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. Covers the water cycle in plants (28 minutes). VHS or Betamax videocassettes; 3/4" U-matic copies also available. Rental: $75.

Water Pollution: A First Film. #72006. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. Describes the water cycle and our part in it; explains the problems and dangers of pollution (12 minutes). Primary and junior high school levels. Video or 16mm film.

Water: A Precious Resource. National Geographic Society, Educational Services, Department 91, Washington, DC 20036, 1-800-368-2728. Students learn where water comes from and, by means of an animated sequence of the hydrological cycle, how water is endlessly recycled (23 minutes). Grades 6-12. Film or video. Rental: $35.

Water: We Can't Live Without It. National Wildlife Federation, 1400 16th St., NW, Washington, DC 20036-3366, 1-800-432-6564. Filmstrip or slides. Cost: $26.95.

Water's Way. #71987. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. A little boy is introduced to the properties and purposes of water by a snowflake that melts in his hand; an introduction to our greatest natural resource—water (7 minutes). Primary and intermediate grade levels. Video or 16mm film.

A

Activity

Water, Water Everywhere

Objective
Students will classify different types of water bodies found on Earth and discuss how people, plants, and animals depend on water for survival.

Setting
Classroom

Duration
1-hour class period

Subject
Science, Social Studies, Language Arts

Skills
Analysis, Classification, Comparing Similarities and Differences, Discussion, Map Reading

Grade Level
K-6 (7-12 using suggested Extension activity)

Vocabulary
Earth water freshwater saltwater

Background Information
Refer to Unit II, Sections A-1, A-3, and A-4.

Materials
A map of the world.

Procedure

1. Using a map of the earth, discuss with students the following:
   - About how much of the earth's surface is water?
   - What types of water bodies are found on earth?
   - Which water bodies are saltwater? Which are freshwater?
   - Why do we need water?
   - Why do animals and plants need water?
   - What types of plants and animals depend most on water and which depend least on water?
   - What would happen to the Earth if all the water on the planet dried up and it stopped raining and snowing? What would happen to plants and animals? What would happen to humans?

Procedure

(continued)

2. Ask students to imagine they are aliens from another world (a dry one) coming to visit Earth. What would they notice about the planet? What different types of water bodies would they find? Where would they go to get away from water? Discuss in class or ask students to write a short composition from the alien's viewpoint.

Extension/ Evaluation

Discuss which plants and animals live in the oceans and which live in freshwater. Ask students if there are any types of animals that can live in both saltwater and freshwater (for example, eels migrate from rivers to the sea for breeding; salmon also pass through estuaries as they swim up rivers for spawning). Help students to conclude that most plants and animals can only live in one type of water or the other and the invisible barrier that prevents them from living in both is salt. The effects of freshwater and saltwater can be observed in the classroom by conducting a simple experiment. Put two eggs in vinegar and leave them overnight. This will remove the hard outer layer of shell. Put one egg in a jar of freshwater and the other in a concentrated salt solution. Discuss what happens after 8 hours. (The egg in the freshwater will burst; the egg in the saltwater will shrink). With older students (grades 9-12), discuss the concept of osmosis and explain that the egg's membrane is similar to the semipermeable cell membrane in an organism. A freshwater organism placed in the sea tends to shrink as water moves through its cellular membranes into the sea, leaving less water in the cells than before. When a marine organism is placed into freshwater, its cells may rupture due to the movement of the water into its cells.

A

Activity

How Wet Is Our Planet?

Objective Students will compute the amount and distribution of water on the earth in oceans, rivers, lakes, ground water, icecaps, and the atmosphere, and make inferences about the importance of responsible use of water.

Setting Classroom

Duration One 40- to 60-minute period

Subject Mathematics, Science

Skills Computation, Description, Discussion, Estimation, Inference, Interpretation, Measuring, Observation, Psychomotor Development, Small Group Work, Synthesis

Grade Level 4-7 (For younger students, this activity can be presented as a demonstration.)

Vocabulary ground water surface water

Background Information Refer to Unit II, Sections A-1 through A-3.

Materials

- A globe, 12 inches in diameter.
- Five gallons of water poured into a 5- or 10-gallon aquarium.
- Writing materials.
- Calculators.
- Measuring cup.
- One quart container for every three students.
- One tablespoon for every three students.

Procedure

1. Review with students, if necessary, that water exists in three forms (solid, liquid, and gas). Explain that water is found on Earth in all three states. Review also the concepts of ground water and surface water with students.
2. Divide the classroom into groups of three. Give each group a quart container and a tablespoon.

Procedure *(continued)*

3. Provide students with the following statistics concerning the amount of water found on Earth:

Water Type	Approximate Amount (in percent)
Oceans	97.2
Icecaps/glaciers	2.0
Ground water	0.62
Freshwater lakes	0.009
Inland seas/salt lakes	0.008
Atmosphere	0.001
Rivers	0.0001
Total	99.8381

4. Show students the aquarium filled with 5 gallons of water. Tell them how much is there. Provide students with the following quantity: 5 gallons = 1,280 tablespoons.

5. Have students assume that the 5 gallons represent all the water on Earth. Ask students to calculate the volume of water for each category listed above using the percentages given. This will require the use of decimals. Remind students that for multiplication, all the decimal places must be shifted two places to the left so that 97.2 percent becomes 0.972 prior to multiplication (0.972 x 1,280 tablespoons = 1,244.16 tablespoons). The following values result:

Water Type	Approximate Amount (in tablespoons)
Oceans	1,244.16
Icecaps/glaciers	25.60
Ground water	7.936
Freshwater lakes	0.115
Inland seas/salt lakes	0.1024
Atmosphere	0.0128
Rivers	0.0012
Total	app. 1,280 tablespoons

Procedure *(continued)*

6. Once the values are obtained, ask the students to calculate the amount of fresh water potentially available (in tablespoons) for human use. The following calculation must be performed:

Water Type	Approximate Amount (in percent)
Icecaps/glaciers	2.0
Ground water	0.62
Freshwater lakes	0.009
Rivers	0.0001
Total	2.6291

Answer: 2.6291 x 1,280 tablespoons = 33.6 tablespoons (or about 34 tablespoons).

7. Ask each group of students to take 34 tablespoons of water from the aquarium, put it in a container, and take the container of water back to their workplaces.
8. At their workplaces, ask the students to remove the amount of water represented by all freshwater lakes and rivers. (It is about 0.111 tablespoon, approximately one-tenth of a tablespoon.) Then ask students to extract the amount represented by just rivers (it is less than one-thousandth of a tablespoon). This amount is less than one drop. Discuss the relative proportions with the students.
9. Discuss that there is a limited amount of freshwater on our planet and that the amount of usable water available to humans is a very small percentage of the total water on the Earth. Discuss how all species depend upon this minute percentage of water for their survival (see the Activity "Water, Water Everywhere"). Also make the point that most freshwater is locked up in icecaps/glaciers and that not all ground water is readily available for human use).
10. Summarize the activity by using a globe to illustrate that if the Earth were this size (12 inches in diameter), less than one-half cup (8 tablespoons) of water would fill all the oceans, rivers, lakes, and icecaps.
11. Conclude by emphasizing the importance of keeping the Earth's waters clean and healthy and of using water wisely and responsibly. Ask what steps students can take to conserve water (see Unit III, Section A-3).

Extension/ Evaluation

Convert the activity to the metric system. The table below shows metric approximations for the quantities used in this activity.

12 inches	3 decimeters
5 gallons	20 liters
10 gallons	40 liters
1,280 tablespoons	2,000 centiliters or 20,000 milliliters
34 tablespoons	52.76 centiliters
1 tablespoon	1.55 centiliters
111 tablespoons	0.182 centiliters
0.0001 tablespoon	0.002 centiliters
1/2 cup	8 tablespoons or 12.5 centiliters

Adapted with permission from: Western Regional Environmental Education Council, Aquatic Project Wild (Boulder, CO: WREEC, ©1987).

A

Activity

The Never-Ending Cycle of Water

Objective

Students will visualize the phases of the water cycle and observe how water changes its state of matter.

Setting

Classroom

Duration

One 30- to 40-minute period initially, and then a few minutes each day (for about a week) for observation and discussion

Subject

Science

Skills

Analysis, Discussion, Inference, Observation, Psychomotor Development, Small Group Work, Visualization

Grade Level

3-8

Vocabulary

gas liquid solid condensation evaporation photosynthesis precipitation transpiration water cycle

Background Information

Refer to Unit II, Sections A-2 and A-4.

Materials

A clear container of any size. Glass jars, aquariums, fish bowls, goblets, and old-fashioned candy jars that can be closed or covered with a clear material make good containers. Large (2-liter) plastic soda bottles with black bottom bases also make good terrariums. Remove the black bottom base and cut off the top stem of the soda bottle. Invert the clear plastic bottle and it will fit snugly into the black base. Students can be asked to bring an appropriate container from home. Each student can make his or her own terrarium, or the class can be divided into partners or small groups.

- One bag each of gravel, peat moss, and potting soil.
- Two types of plants either collected or purchased. Common terrarium plants include:
  - Native Plants—hawkweed, mosses, evergreens, shelf fungus, violets, wild strawberry, wintergreen.
  - Greenhouse plants—baby's tears, dwarf English ivy, ferns, Japanese aucuba, philodendron, begonias, creeping fig, Swedish ivy.

Materials *(continued)*

Note: Some very rare wild plants are protected by law. If you are collecting plants yourself, be sure to check state and federal laws regarding collection. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!")

Procedure

1. Cover the bottom of the plant container with 1 inch of gravel for drainage.
2. Put a layer of peat moss over the gravel.
3. Put a layer of soil over the gravel and peat moss.
4. Make two small holes in the soil and place plants in so that roots can be covered. Pack the soil around the plants and press firmly. Do not crowd the plants.
5. A small decoration (covered rock, shell, or piece of bark) may be added to the terrarium to make it ornamental.
6. Water the terrarium lightly and cover it with a lid or plastic wrap. (If you are using a soda bottle, use the inverted, clear plastic bottle as your lid.) The terrarium will need only 1 or 2 teaspoons of water a month.
7. Place the terrarium in a sunny location.
8. Discuss, if necessary, that water exists in three states of matter: solid, liquid, gas (one or more of the activities provided below in "Extension/Evaluation" may be useful for this discussion). Describe the water cycle to students, using the master provided.
9. After a few days, observe the terrarium and ask students:
   - What has collected on the sides of the glass jar?
   - Where did the moisture on the sides of the jar come from?
   - What provided the energy for the changes observed in the water's form?

Explain that the terrarium is actually a model of the natural water cycle. The plants take up the water through their roots and release it through their leaves (transpiration). The water molecules will condense on the glass (condensation) and fall back into the soil just like rain (precipitation). Some of these water molecules will also be evaporated by the sun. The plants will use the moisture in the soil for photosynthesis, a process that occurs in the plants' cells and provides energy for the plants' growth.

Extension/ Evaluation

Illustrate the concept of water vapor by having one or more students exhale close to the blackboard so that the moisture from their breath forms a dark, wet spot. Trace the spot with chalk and ask why the spot is darker than the rest of the board. Ask where the moisture came from. Fan the spot so that it disappears. Write the word "evaporation" on the board. Discuss the root word "vapor." Ask students what other forms of water vapor they are familiar with (water from a steaming kettle, water from a vaporizer).

Have the children paint a watercolor picture of the Ohio River, and of the types of animals and plants found in and around the river. When the paint is dry, ask children what happened to the water (used to mix the paint) on the paper? Discuss the concept of evaporation.

Fill a kettle half full with water. Using a hot plate, heat the water. When the water starts to boil, steam will come out of the spout. Hold a metal tray of ice cubes over the steam. Place another tray beneath this one. When the steam hits the tray of ice cubes, condensation will form. The water vapor being cooled as it hits the tray will form liquid droplets and fall into the catch tray below. Discuss the concept of condensation.

As a class, create a mural of the water cycle.

B Chemical and Physical Properties of Water

1 The Molecular Structure of Water

Water is made up of molecules. Every molecule of water is made up of two hydrogen atoms chemically bonded to an oxygen atom. (An atom is composed of a nucleus, which is positively charged, around which negatively charged electrons orbit.) Molecules are held together in fixed proportions by attractive forces called bonds. In water, the molecules are held together by weak hydrogen bonds. These bonds are responsible for many of the physical properties of water, such as its surface tension (described below).

The water molecule is a polar one, meaning that oxygen is much more electronegative than hydrogen, and therefore tends to "pull" electrons to its side of the molecule, like bedcovers pulled to one side of a bed. Atoms (or groups of atoms) that have lost or gained one or more electrons are called ions. Every ion has a net positive or negative charge. The number of positive or negative charges is shown as a superscript after the symbol for an atom or group of atoms. The water molecule consists of two ions: H^+ (hydrogen ion, which is positively charged) and OH^- (hydroxyl ion, which is negatively charged). The polar nature of water is very important in its function as a solvent (see Section IIB-7).

2 pH

Whenever the H^+ concentration equals the OH^- concentration in a solution, as it does in pure water, the solution is said to be neutral. A solution is acidic when the H^+ concentration is greater than that of pure water. Conversely, a solution in which the H^+ concentration is lower than that of pure water is basic or alkaline.

Different levels of acidity and alkalinity of water solutions are expressed in terms of pH. The pH scale ranges from 0 to 14, with each whole number decrease in pH representing a tenfold increase in acidity. A neutral solution has a pH of 7. A substance with a pH greater than 7 is a base, and one with a pH below 7 is an acid. The higher the pH above 7, the more basic the substance. In the same way, the lower the pH below 7, the more acidic the substance.

Pure water has a pH of 7; however, the pH of water depends upon the environment that it passes over since water can dissolve substances that can change its pH. For example, water passing over limestone becomes more alkaline (or basic). In fact, limestone is sometimes added as a **buffering agent** to acidic waters to help **neutralize** them. The pH of a water body plays an important part in the distribution of plants and animals in that environment. For example, mollusks with limy shells cannot live in acidic waters. (See Unit III, Section B-6 for more information on the effect of pH on wildlife.)

3 Surface Tension

Surface tension is the tendency of a liquid surface to resist penetration. It is created because water molecules at the surface are attracted more to other water molecules than to air. As a result, the surface water molecules are attracted to each other and pulled tightly together by attractive forces of water from underneath, thereby producing surface tension. Surface tension decreases with increasing temperature and increases with increasing salinity.

Surface tension is very important in supporting the weight of organisms that rest on the surface of water, such as the water strider (a pond insect). The water strider has special hairs on its first and third pair of legs that rest on the water's surface layer (the "skin" that separates bodies of water from the surrounding atmosphere). The strider's second pair of legs penetrate the water and work like oars to propel the insect over the surface.

Some kinds of beetles, water bugs, and free-floating plants are adapted to life only on the upper side of the surface layer. The larvae of some beetles and flies spend much time hanging on the underside of the surface layer. Surface-dwelling animals feed on floating plants, on one another, or on insects and other animals that have died and now float on the surface.

4 Heat Capacity

Water has one of the highest known **heat capacities** (the amount of heat required to raise the temperature of 1 gram of a substance by 1 degree Celsius). A calorie is the amount of heat required to raise the temperature of 1 gram (about 1/5 teaspoon) of liquid water by 1 degree Celsius; a dietary Calorie is equivalent to 1,000 calories. The dietary Calorie is distinguished from the calorie defined above in that the dietary Calorie is always capitalized.

The heat capacity of pure water is 1 calorie/gram (cal/gm). That is, it takes 1 calorie of heat energy to raise 1 gram of water (about 10 drops) 1 degree on the Celsius temperature scale. In contrast, the heat capacity of iron is only about 0.1 cal/gm; that of aluminum, nitrogen, and oxygen is about 0.2 cal/gm; and that of wood is 0.33 cal/gm.

Because of its high heat capacity, water has a built-in ability to resist changes in temperature. As a result, water warms and cools much less rapidly than land or air.

5 Temperature

Water bodies vary greatly in **temperature**, according to latitude, altitude, time of day, season, depth of water, and many other variables. The temperature of a water body determines what aquatic species may be present. It also controls the spawning and the hatching of young creatures; regulates the activity of all organisms (both those with a constant body temperature and those with a body temperature that fluctuates with changes in the temperature of the surrounding environment); stimulates or suppresses the growth and development of organisms; and can either attract or kill organisms when the water becomes heated or chilled too suddenly.

Under calm conditions, a body of water may become layered or **stratified**, with regions of different water temperature. These different temperatures can play a major role in determining the distribution of living organisms. For example, in summer, the surface water of a lake absorbs the sun's heat and warms faster than the water below. Some animals, like trout, may therefore concentrate in the cooler, lower depths. Seasonal temperature fluctuations that cause stratification also play a role in the distribution of nutrients and dissolved gases (see Unit II, Sections B-7 and B-8 below).

6 Density

The **density** (the weight per unit volume) of water is greatest at 4 degrees Celsius (39.2 degrees Fahrenheit). It becomes less dense as water warms. For example, in spring, when the sun warms the surface of ponds and lakes, a warm layer of water forms that floats above the cool deep water. The transition zone between the warm and cold water is called the **thermocline**. The thermocline is characterized by a sudden drop of temperature.

As water cools to freezing (0 degrees Celsius), it changes to ice, which is less dense than liquid water and floats. The fact that ice floats is important to aquatic life. If ice sank, the sea floor might be covered with ice, the polar seas would freeze solid, and some lakes at high altitudes would freeze in the winter and many would never completely thaw in summer. This would greatly restrict the distribution of aquatic life (particularly of those organisms that dwell on the bottom).

Freshwater is also less dense than saltwater. In estuaries (where a river meets the sea), or where ice floes are formed, freshwater floats above saltwater.

7 Solubility

Water **dissolves** more substances than does any other liquid. For this reason, water is called the universal solvent. Table salt and sugar are among the many substances that form a solution with water (that is, they dissolve completely, mixing with the water and staying mixed). Some substances appear to mix completely, but do not go into solution. When they are allowed to sit undisturbed, they settle out. These compounds are said to form a **suspension**. (Cornstarch is an example of a household compound that forms a suspension with water.) The more suspended or stirred up particles or sediments there are in a water body, the higher its **turbidity**.

Various gases, including oxygen, are soluble in water. Because all living things depend on oxygen in one form or another, **dissolved oxygen (DO)** is of great significance in the aquatic environment. Oxygen enters the water by absorption directly from the atmosphere or through photosynthesis (See Unit I, Section B-1 for a description of this process). It is removed by the respiration of organisms and by decomposition. Agitation of a water body by wind or other movement may also release dissolved oxygen. Fast, cascading streams are rich in oxygen; slow-moving, stagnant waters are oxygen-poor. The solubility of oxygen in water varies inversely with temperature, so as waters become warmer, there is less available dissolved oxygen in the water. The cooler the water, the more dissolved oxygen it will hold.

8 Nutrients

Nutrients are chemicals, such as phosphorus and nitrogen, that are needed for a plant's growth. Nutrients are added to a body of water through either human activities (such as from sewage treatment plants' effluents or runoff of fertilizers) or natural occurrences (such as soil erosion, as described in Unit III, Section B-1). Water bodies rich in nutrients are said to be **eutrophic**. In eutrophic waters, tremendous growths (blooms) of phytoplankton, such as algae, often occur. Dense algal growths may form surface water scums and generate foul odors. They can also inhibit light penetration. As nutrient levels increase, the number of species present also declines as less tolerant organisms die.

The distribution of nutrients in a body of water is affected by seasonal changes in temperature. For example, during winter, the surface water is warmed much more quickly than deeper water and it becomes lighter. The water becomes stratified and little mixing occurs. Nutrients near the surface of the water are depleted, but nutrients are built up near the bottom because the "rain" of dead organisms from above is decomposed in the deeper water.

9 Velocity

A river's current flows in one direction. The speed or **velocity** of the current differs in different parts of the river and at different times of the year. In general, the greater the **volume** of the river, the greater its velocity. Thus, large rivers generally flow faster than small ones. Velocity can also increase in accordance with the steepness, narrowness, or shallowness of the stream bed. It may be slowed by turbidity or by friction along the shore, with the bottom, or at the surface.

The velocity of water movement is important to aquatic organisms in a number of ways, including the transport of nutrients and the addition of oxygen to the water through surface aeration. Flow can also move silts and transport sediments, as well as the nutrients associated with sediments (such as nitrogen and phosphorus). In addition, flow determines those species of organisms that may be present in a particular river or stream. Some organisms such as the black fly larva require fast water; others, such as immature forms of caddisflies and mayflies, will tolerate more sluggish waters. (See Unit I, Section C-2 for more information on the types of organisms that live in fast- and slow-moving waters.)

10 Indicator Species

Animals have differing sensitivities to environmental conditions. In streams and ponds, the presence or absence of certain organisms, called **indicator species**, reveals much about the quality of the water. For example, those animals that are able to live in highly polluted waters, mainly because they are tolerant of a reduced oxygen supply, include rat-tailed maggots, midge larvae (bloodworms), sewage fly larvae, and sludgeworms. Organisms that are somewhat tolerant of polluted conditions include scuds, sowbugs, flatworms, cranefly and blackfly larvae, gill snails, fingernail clams, leeches, dragonfly nymphs, and damselfly nymphs. Organisms that are sensitive to pollution and live in clean-water environments include stonefly nymphs, mayfly nymphs, caddisfly larvae, water pennies, riffle beetles, unionid clams, and fish fly larva. These creatures comprise a biotic index that provides a "living indicator" of the amount of pollution present in a water body.

Water with a rich and varied range (or **diversity**) of aquatic creatures is usually a **healthy environment** (one supportive of life). Water with just a few species usually indicates less healthy conditions. Pollution generally reduces the quality of the environment and, in turn, the diversity of life forms.

Resources

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Audiovisual Programs

Element 3. International Film Bureau, 332 South Michigan Avenue, Chicago, IL 60604-4382, 312-427-4545. A look at the contrast between the lyrical beauty of pure water and the aridity of its absence; focuses on the cooperation that is essential for the distribution of water. Video or 16mm film.

Learning About Air and Water. National Geographic Society, Educational Services, Department 91, Washington, DC 20036, 1-800-368-2728. Covers the basics about air and water, including interactions in the water cycle, as well as causes of pollution (19 minutes). Grades 4-9. Film or video. Rental: $25.

Water: A First Film. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. Describes the importance of water to plants, animals, and the Earth (12 minutes). Primary and intermediate grade levels. Video or 16mm film.

Water's Way. #71987. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. A little boy is introduced to the properties and purposes of water by a snowflake that melts in his hand; an introduction to our greatest natural resource—water (7 minutes). Primary and intermediate grade levels. Video or 16mm film.

B

Activity

A Change in the Weather

Objective

Students will learn to read a thermometer, compare temperatures in water and in air, apply the results of the experiment to the natural environment, and make generalizations about the relative seasonal temperature changes likely to be found in large and small bodies of water.

Setting

Classroom

Duration

One 20-minute period and one 40- to 60-minute period

Subject

Chemistry, Mathematics, Science

Skills

Analysis, Application, Comparing Similarities and Differences, Computation, Discussion, Evaluation, Generalization, Observation, Prediction, Problem-Solving, Psychomotor Development

Grade Level

4-8

Vocabulary

temperature heat capacity

Background Information

Refer to Unit II, Section B-4.

Materials

For each group:

- Three clear containers (two of the same size and one four times as big). The two containers that are of the same size should also be of the same material, such as two pint bottles, two plastic soft drink bottles, or two fruit jars.
- Lids or aluminum foil to cover tops of containers.
- Three safe, breakproof thermometers.
- Water.

For the class:

- An ice chest or refrigerator.

Procedure

1. Introduce the exercise by asking the students which they think would be warmer on a hot day: a fish living in a big lake or a turtle sitting on a log next to the lake? How about in the dead of winter when snow is piled up—would it be colder under the ice in the pond or on the shoreline? (Generally, the temperature is more moderate in water than on land.) Ask the students if they have ever thought about why the climate is more moderate under water.

2. Fill one of the smaller containers and the larger container with water at room temperature, leaving a space at the top in case it freezes. Leave the third container filled with air. Add thermometers to each jar and record the time and temperature for each. Cover each jar with the foil or put lids on loosely. Put the jars in a cold location (a refrigerator, ice chest, or outside on a cold day). Leave overnight or until temperature near freezing is reached.

3. The next day, remove the jars of cold water and air, and place on desks where students can read the thermometers. For the next 1/2 hour (or until the temperatures stop changing substantially), periodically (about every 5 to 10 minutes) record the time and temperature in each jar.

4. Ask students to calculate the rates of change for each sample by dividing the total temperature change (from start to finish) by the total elapsed time (minutes the experiment ran). The large body of water should change more slowly than the smaller one. Water should change more slowly than air. If you used small jars with a lot of surface area, the water may not seem much different from the air.

5. Ask students to apply the results to the environment by discussing the following questions:

   - Which animals are exposed to the most radical temperature changes—those that live in the water or those that live on the land?
   - Can any generalizations be made about the relative seasonal temperature changes likely to be found in a pond, a lake, the ocean? (Small ponds show greater changes in temperature with the seasons; lakes show less; and oceans show the least amount of changes. But even oceans, at least at the surface, have temperature changes).
   - If an animal needs to stay at nearly the same temperature all year, would it prefer to spend the winter and the summer in a big body of water or a little pond? (The bigger the body of water, the smaller the changes with the season.)

Procedure

(continued)

Discuss with students that water has one of the highest known heat capacities.

Extension/ Evaluation

Perform another experiment to determine whether air or water warms more quickly. Use two jars of the same size and material. Fill one with room temperature water and leave the other filled with air. Place both jars under an incandescent light (which will serve as a heat source). Make sure the jars are not sealed so that the air has room to expand as it warms. Over the next 1/2 hour or so, periodically (every 5 minutes) take the temperature of the two jars, recording the results in a notebook. Determine which warmed more quickly (air should warm more quickly) and relate the results of the experiment to the environment.

Adapted with permission from: National Aquarium of Baltimore, Living in Water, 2nd ed. (Baltimore, MD: Department of Education, National Aquarium of Baltimore, 1989).

B

Activity

In Hot Water

Objective

Students will study the relationship between water temperature and density, define a thermocline, and discuss the ecological significance of stratification and mixing.

Setting

Classroom

Duration

One 40- to 60-minute period

Subject

Chemistry, Mathematics, Science

Skills

Comparing Similarities and Differences, Discussion, Evaluation, Observation, Psychomotor Development, Small Group Work

Grade Level

6-10

Vocabulary

density stratification thermocline

Background Information

Refer to Unit II, Sections B-5 and B-7.

Materials

For the class:

- Hot tap water.
- Cold water (from refrigerator or ice water). If you don't have access to a refrigerator, plan to do this activity early in the morning and bring ice cubes from home. If you do not have an ice chest, put the ice cubes into watertight plastic bags and wrap them in newspaper.

For each group:

- Four clear plastic cups.
- A plastic spoon.
- A bottle of food coloring.

Procedure

1. Divide the class into groups of three or four. Give each group four clear plastic cups, a plastic spoon, and a bottle of food coloring.
2. Ask each group to fill two of its cups with hot tap water (but not so hot that it could burn a child's skin) and the other two with cold water, and to take these cups back to their workstations.

Procedure *(continued)*

3. At their workstations, ask the students to add a few drops of coloring to one of the hot water cups and one of the cold water cups. Next, ask the students to take a spoonful of the cold colored water and very carefully pour it on the surface of the hot clear water. Observe what happens. (The cold colored water, which is denser than the hot clear water, should sink.)

4. Now, ask the students to try the reverse. Take a spoonful of hot colored water and pour it on the surface of the cold clear water. What happens? (The hot water should float on the surface of the cold water because it is less dense.)

Note: As a control, you might demonstrate to students what happens when a spoonful of hot colored water is added to a cup of clear hot water, and when a spoonful of cold colored water is added to a cup of cold clear water.

5. Discuss how a body of water can be stratified, or layered, with two totally different kinds of places (in terms of temperature) for plants and animals to live. Ask students if they know what the zone between the two layers (warm and cold) is called? (A thermocline.) Ask students if they have ever noticed a sharp drop in temperature while swimming in a lake or pond, and explain that this is the thermocline.

6. Ask the students to stir the water and observe what happens (the water becomes mixed). Discuss what "stirs" real water (wind). Discuss why mixing is ecologically important in a body of water (for example, provides oxygen, helps transport nutrients).

Note: You might want to try this activity at home before conducting this experiment in the classroom. It may be difficult to add the spoonful of water so that the proper layering occurs. If so, another simple way to demonstrate the principles of this lesson is to fill a small balloon with very cold water (place a water balloon in the refrigerator) and drop it into an aquarium filled with hot water. Observe whether it sinks or floats (it should sink). Leave the balloon in the water and observe what happens when it warms up (it rises).

Extension/ Evaluation

Investigate what happens when a pond or lake freezes by having the students make a model pond. Fill a plastic cup with cold water. Put several Styrofoam® cups inside one another and then place the plastic cup inside the Styrofoam® cups (the Styrofoam® will help insulate the plastic cup). Check the cup every 15 minutes. Where does the ice form first? Record when the ice forms and where. If a pond works in the same way, where does the ice form first? (Do not try to freeze the water in the cup solid as it may burst.)

Extension/ Evaluation

(continued)

Demonstrate why ice floats by filling a clear plastic cup with cold water. Draw a line at the top of the water with an insoluble marker. Put the water in a freezer overnight. The next morning, compare the level of the frozen water with the line. What has happened to the water? What does this say about the density of frozen water compared to liquid water?

Adapted with permission from: National Aquarium of Baltimore, Living in Water, 2nd ed. (Baltimore, MD: Department of Education, National Aquarium of Baltimore, 1989).

B

Activity

Pondering pH

Objective

Students will determine the pH of various substances, differentiate between acidic and basic substances, and make generalizations about the effect of pH on the aquatic environment.

Setting

Classroom

Duration

One 40- to 60-minute period

Subject

Science

Skills

Analysis, Application, Classification, Comparing Similarities and Differences, Definition, Discussion, Generalization, Observation, Psychomotor Development, Small Group Work, Synthesis

Grade Level

3-8 (This activity can be done as a demonstration for younger children.)

Vocabulary

acid base pH pH scale neutralize buffering agent

Background Information

Refer to Unit II, Section B-2.

Materials

For the class:

- Distilled water (available at grocery stores and drug stores).
- White vinegar.
- Baking soda.
- Measuring cups (1/2 cup and 1/4 cup) and teaspoons (1/2 teaspoon).

For each group:

- Litmus paper and pH chart.
- Three small, clear cups.
- Three stirring spoons.
- Notebook and pencil.
- Copies of the Scale of pH handout (make enough copies so that each student in the class can have a copy).

Procedure

1. Explain to the students that they will be measuring the pH of various solutions using Litmus paper, a specially treated paper that changes color in acidic or basic solutions.
2. Divide the students into groups of three or four. Give each group three cups, three stirring spoons, and Litmus paper. Ask the students to label one cup vinegar, one cup baking soda, and the third cup water.
3. Ask each group to bring their cups to a central workstation, where they should rinse each cup with distilled water and shake out the excess water. Next, have the students measure and pour 1/2 cup of distilled water into each of the three cups.
4. Have the students add 1/2 teaspoon of white vinegar to the vinegar cup and stir with a clean spoon. Add 1/2 teaspoon of baking soda to the baking soda cup and stir with a clean spoon. Do not add anything to the water cup.
5. Have the students take the cups back to their workstations. Ask the students to dip an unused, clean strip of pH paper in the vinegar cup for about 2 seconds and immediately compare it with the color chart. Write down the approximate pH value. Is the vinegar an acid or a base? (Vinegar is an acid and turns pH paper yellow or red.)
6. Next, the students should dip an unused, clean strip of pH paper in the baking soda cup for about 2 seconds and immediately compare to the color chart. Write down the approximate pH value and set the cup aside. Is the baking soda an acid or a base? (Baking soda is a base and turns most pH papers blue.)
7. Dip an unused, clean strip of pH paper in the water cup for about 2 seconds and immediately compare to the color chart. Write down the approximate pH value and set the cup aside. Is the water an acid or a base? (Pure distilled water is neutral, but pure distilled water is not easily obtained because carbon dioxide in the air mixes in the water, making it somewhat acidic. To neutralize distilled water, add about 1/8 teaspoon of baking soda or a drop of ammonia, stir well, and check the pH again. If the water is still acidic, repeat the process until a pH of 7 is reached.)
8. Ask students to guess whether some common household products (such as lemon juice, tomatoes, milk, shampoo, ammonia, black coffee, soap solutions, oven cleaner) are acidic or basic. You might test some of these substances in the classroom. Give each student a copy of the Scale of pH handout.

Procedure *(continued)*

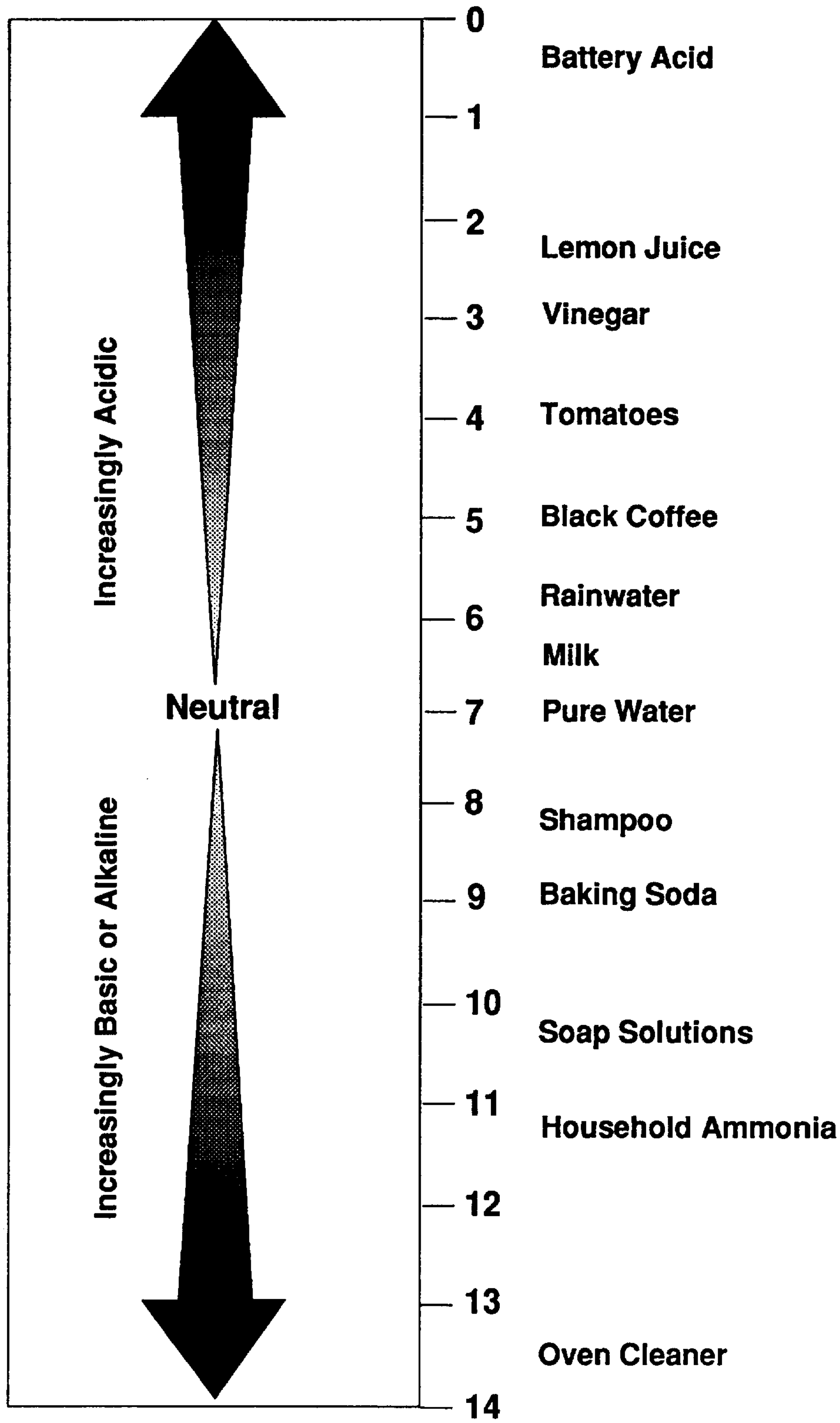
9. Discuss how the pH of a water body could affect the plant and animal life that grows there. You might ask older students if there are certain chemical properties that very acidic substances (like automobile battery acid) and very alkaline substances (like household drain cleaners) have that could harm plants and animals? (They are reactive and can cause severe burns.)

10. Discuss how the pH of a water body could change over time. What kinds of substances could enter the water to change its pH? (Some examples are effluents and fertilizers.) Where would these substances come from? (industry, agriculture) Is there anything that people could do to make the pH of a water body neutral? (Add buffering agents like lime to acidic waters.) See Unit III, Section B for a discussion of acid rain, another problem that affects the acidity of water bodies.

Extension/ Evaluation

Students can make a natural pH indicator in the classroom or at home from red cabbage. Red cabbage contains a chemical that turns from its natural deep purple color to red in acids and blue in bases. Boil the cabbage in a covered pan for 30 minutes (or microwave for 10 minutes). Let the cabbage cool and then remove it. Pour about 1/4 cup of cabbage juice into 2 clear cups. Add 1/2 teaspoon of baking soda to one cup and 1/2 teaspoon of vinegar to another cup. Stir each cup with a clean spoon and observe the color changes that take place. (The vinegar and cabbage juice mixture should change from deep purple to red, indicating that vinegar is an acid; the baking soda and cabbage juice mixture should change from deep purple to blue, indicating it is a base.) Pour the contents of the vinegar cup into the baking soda cup. Does the color change? (Yes, the color should change from blue or red to purple.) What does this tell you about the solution? (It has become neutralized.)

Scale of pH


0
Battery Acid
1
2
Lemon Juice
3
Vinegar
4
Tomatoes
5
Black Coffee
Rainwater
6
Milk
7
Pure Water
8
Shampoo
9
Baking Soda
10
Soap Solutions
11
Household Ammonia
12
13
Oven Cleaner
14
Increasingly Acidic
Neutral
Increasingly Basic or Alkaline

B

Activity

The Disappearing Act

Objective

Students will compare rates at which different substances dissolve in water and define different factors that affect the rates at which some substances dissolve.

Setting

Classroom

Duration

One 40- to 60-minute period

Subject

Chemistry, Mathematics, Science

Skills

Analysis, Application, Classification, Computation, Description, Discussion, Generalization, Graphing, Observation, Psychomotor Development, Small Group Work

Grade Level

4-9

Vocabulary

dissolve suspension solution

Background Information

Refer to Unit II, Section B-7.

Materials

For the class:

- Water.
- Table salt (use canning or kosher salt).
- Granulated table sugar.
- Cornstarch.
- Large clear glass jar.
- Package of a dark flavor of unsweetened Kool-aid®.

For each group:

- Three clear plastic cups.
- Three plastic straws or stirrers.
- A teaspoon.
- A graduated measuring cup.
- Three pieces of tape or sticky labels.
- Pencils or pens.
- Notebooks.

Procedure

1. Show the students a large, clear glass jar of water and a package of unsweetened Kool-aid®. Ask them to predict what will happen if you pour the Kool-aid® into the water. Do they all agree? Pour the Kool-aid® in and see what happens (it should sink and then begin to dissolve and spread through the water). Ask students if they can suggest a way to speed up the process of dissolving (stirring, use hot water). Introduce the word "solution" for the mixture and the word "dissolve" for the process of mixing completely.

2. Ask students to name other substances found around the house that would dissolve in water. List them on the blackboard. Show the students the table salt, sugar, and cornstarch. Ask them to predict whether each will go into solution.

3. Divide the students into groups of three or four. Each group should label one clear plastic cup as "salt," another as "sugar," and the third as "cornstarch." Fill each of the three plastic cups with about the same volume of water at room temperature. Leave about 1 inch of space at the top.

4. Add 2 heaping teaspoons of salt to the cup labeled "salt," 2 heaping teaspoons of sugar to the "sugar" cup, and 2 heaping teaspoons of cornstarch to the "cornstarch" cup. Have the students observe what happens for 2 minutes and record their observations in a notebook. Then ask the students to stir each cup by making a circle around the edge of the cup with the stirrer ten times. Was there a change? Repeat, stirring ten times in each cup until one substance has completely disappeared or dissolved. Record how many times this cup was stirred. Continue stirring and observing the other two substances to find out which dissolves (or disappears) next fastest. Again, record the results. Each group should have three numbers (the number of times each substance was stirred before it was dissolved).

5. Have each group post its results on the blackboard. Compare the results among the groups and discuss the results. (Sugar or salt may be faster depending on the size of the crystals in the particular brand; what happens to the cornstarch may be the subject of debate. Some students will say it is in solution, others may not.) For each substance, add all of the numbers obtained for that substance and divide by the number of groups to get an average result. Have students make a bar chart of the average numbers.

6. Save two sets of the solutions and place them in a safe place overnight. The next day, ask students to observe what has happened to the solutions (the cornstarch will have settled out). What conclusions can be drawn from these observations? (Not all substances go into solution, and some dissolve faster than others.)

Procedure *(continued)*

7. Ask the students if gases, such as oxygen, go into solution in water? Help the students to understand how oxygen enters the water and how it is used by organisms. Discuss with students the importance of oxygen to living things.

Extension/ Evaluation

Ask students to design an experiment to test whether substances go into solution faster in hot water. They should be able to state the central question to be addressed through the experiment, design a procedure for carrying out the experiment, and determine an appropriate control for comparison. Then have the students carry out the experiments that they designed.

Adapted with permission from: National Aquarium of Baltimore, Living in Water, 2nd ed. (Baltimore, MD: Department of Education, National Aquarium of Baltimore, 1989).

B

Activity

Go with the Flow

Objective

Students will compute the velocity of a creek or stream, and explore the relationship of velocity to different habitats, as well as the kinds of species that live in those habitats.

Setting

Outdoors, at a small creek or stream

Duration

1/2 day to a full day if combined with other field activities, such as "Stream Study," which is also found in Unit II, Section B

Subject

Mathematics, Physics, Science

Skills

Analysis, Application, Comparing Similarities and Differences, Computation, Generalization, Observation, Psychomotor Development

Grade Level

6-12

Vocabulary

velocity volume

Background Information

Refer to Unit II, Section B-9.

Materials

- String (measured and cut to 100 feet and marked in 1-foot intervals for the first 15 feet of string).
- A yardstick.
- Ping pong ball (painted a bright color).
- Stop watch.
- Pencils and notebooks.
- Copies of Water Flow Chart.

Procedure

1. Using the string, have the students mark off a 100-foot section of the stream or creek. (You might position a student at each end of the measured section, or otherwise mark it, so you can discern where the section begins and ends.)
2. Now use the string to make several measurements of the width of the creek within the 100-foot measured section. Record these numbers in a notebook.

Procedure

(continued)

3. Have the students measure the depth of the creek using the yardstick. Again, ask the students to take several measurements of the depth of water along the measured section and to record these numbers in a notebook.
4. Average the measurements to get a single number for water depth and creek width.
5. Multiply width x depth x length (100 feet) to get the volume of water in that section of the creek.
6. Have a student start the ping pong ball at the top of the measured section. Another student at the bottom should act as the timer. Allow the ball to float through the "course" several times. Record how long it takes for the ping pong ball to reach the bottom each time, and then average the results.
7. View the creek as a unit of volume per unit of time. How much water flows by in 1 second, 1 minute, 1 hour? Record the answers on the Water Flow Chart. Determine if the creek is a relatively fast- or slow-moving one.
8. Have students note what types of animals and plants live in the stream. What do they look like? What are their shapes? (See Unit I, Section C for more information about plant and animal species.) Help the students to understand the relationship between the types of plants and animals present and the velocity of the stream.

Extension/ Evaluation

You can observe how different shapes affect the speed of an organism in water by conducting a simple experiment. Using an aquarium or a long pan filled with water, measure off a 1-foot section with a wax crayon. Put a mechanical or battery-powered toy in the water and record how long it takes for the toy to travel the length of the marked-off section. Then, change the shape of the toy by gluing fin-like shapes that you have cut from a plastic bottle at different positions and angles along the toy. Repeat the experiment and discuss how the alterations affected the speed and direction of the toy.

Water Flow Chart

Time	Volume of Water
1 Second	
1 Minute	
1 Hour	

B

Activity

Life at the Surface

Objective The students will be able to define surface tension and observe its relationship to living organisms.

Setting Classroom

Duration One 40- to 60-minute period

Subject Art, Language Arts, Mathematics, Physics, Science

Skills Analysis, Application, Discussion, Invention, Media Construction, Observation, Research, Synthesis, Writing

Grade Level 4-10

Vocabulary surface tension

Background Information Refer to Unit II, Section B-3.

Materials

For each student:

- A cup of water.

For the class:

- A box of "model parts," which might include toothpicks, thin wire, string, straight pins or needles, clay, staples, wooden or plastic coffee stirrers, wire screen, pieces of a plastic strawberry basket.
- Glue or tape, if needed.
- A scale or triple beam balance.
- A large container (like an aquarium or a large, transparent pan or bowl) filled with water.

Procedure

Prior to this experiment, begin a discussion of the creatures that live on the surface of the water (such as the water strider or whirligig beetle) and their special adaptations for this environment. Discuss the term "surface tension." Have students choose one of these animals and perform research on it. Ask students to write a descriptive paragraph and draw a picture of the animal they choose. Post the paragraphs and pictures in the classroom.

Procedure

(continued)

1. Provide students with a box of "model parts" (see the list in "Materials" above). Tell students they will be designing a creature that, like the water strider or whirligig beetle, can "walk on top of water," with its weight supported by surface tension.
2. After designing their model creatures, have each student bring their "creatures" to the front of the room. Allow them to place their models, one at a time, on the surface of a large, clear container of water in full view of the class. Weigh the ones that are successful. The student that designed the heaviest model is the winner.
3. Initiate a followup discussion concerning which model shapes and parts worked best. It will probably be clear that the models with their weight evenly distributed over the surface area, not all in one spot, worked best.

Extension/ Evaluation

If any students live near a pond, ask them if they can safely collect several water striders to bring to the class. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!") In class, have the students observe the water striders and watch how they "walk on water." If your class has set up a freshwater aquarium (see Unit I, Section B and Appendix A, "Keeping Classroom Aquaria—A Simple Guide for the Teacher"), add the water striders to the aquarium. The students may also see how the water striders deal with hungry fish.

To further demonstrate surface tension, divide students into pairs and give each pair a penny, an eyedropper, and a small container of water. Have students squeeze drops of water one at a time onto the surface of the penny, counting each drop. Have them observe what happens. Ask students how many drops of water they were able to add before the rounded bulge finally broke. Ask each group to write its number on the board. Then have students add the numbers and calculate the average number of drops added before the surface tension "stretched" too far.

Adapted with permission from: National Aquarium of Baltimore, Living in Water, 2nd ed. (Baltimore, MD: Department of Education, National Aquarium of Baltimore, 1989).

B

Activity

Dirty Water

Objective

Students will compare the effects of various levels of nutrients on water and discuss the results of eutrophication on an aquatic environment.

Setting

Classroom

Duration

One 20-minute class period; four 10-minute class periods (one per week for 4 weeks); and one final 20-minute class period

Subject

Chemistry, Mathematics, Science

Skills

Analysis, Application, Comparing Similarities and Differences, Discussion, Generalization, Psychomotor Skills, Observation

Grade Level

4-10

Vocabulary

algae erosion nutrients turbid

Background Information

Refer to Unit II, Section B-8 and Unit III, Section B-1.

Materials

- Five clear containers, one quart or more (plastic soft drink bottles or canning jars are ideal).
- Water with algae from freshwater aquarium, a pond, or purchased pond water from a biological supply company.
- Soil from a yard or flower bed or garden, or potting soil.
- Cloth to filter soil from water.
- Plant fertilizer.
- Aged tap water.
- Good light source, either indirect sunlight or strong artificial light.
- Camera and roll of 12-exposure print film (35 mm is best).

Procedure

1. Before class, mix 2 cups of soil with 1 quart of water and shake vigorously. Let the mixture sit until the dirt settles and then strain the water through cloth into another container.
2. In the classroom, add soil to water in one of the jars and shake. The water becomes turbid as soil particles become suspended. Discuss some causes of turbidity and how an increase in turbidity in a water body affects plants and animals that live there. Put the jar aside for future observation.

Procedure *(continued)*

3. Add tap water to one of the other jars and label it "control." Fill two of the three remaining jars with tap water and label one "1 tsp fertilizer" and the other "2 tsp fertilizer." To the last jar, add water you prepared in Step 1 (explain that this water was prepared in the same manner as the shaken soil and water demonstration). Label this jar "soil." Add 1 teaspoon of fertilizer to the jar labeled "1 tsp fertilizer," and 2 teaspoons of fertilizer to the jar labeled "2 tsp fertilizer." Now add aquarium water with algae or pond water with algae to each jar. Use equal amounts, up to one cup each. Set all three jars where there is good light.
4. For the next 4 weeks, take photographs of the jars side by side in good light from close up once each week. Write the date on a piece of paper that shows in the photograph and make sure the labels on the jars show. Keep the jars in the same place in each photograph.
5. After a month has passed, develop the photographs and arrange them in order. Discuss the changes that were recorded. The jars with the soil water and fertilizer should show a much more luxurious growth of algae than the plain tap water. Discuss why this has happened. Observe if there was a difference in the amount of algae growth with the two different dosages of fertilizer.

Discuss what nutrients are and where they come from (erosion, runoff, etc). Also discuss whether nutrients are "good" or "bad." (Nutrients are good initially because they help promote plant growth. Too many nutrients, however, can generate water scums and foul odors, and inhibit light penetration). Help students understand the term eutrophication.

Extension/ Evaluation

Study the label of the plant fertilizer to discover what some plant nutrients are. The label will probably list compounds containing nitrogen, phosphate, and potassium. Many brands have a number of other chemicals as well.

Adapted with permission from: National Aquarium of Baltimore, Living in Water, 2nd ed. (Baltimore, MD: Department of Education, National Aquarium of Baltimore, 1989).

B

Activity

Stream Study

Objective

Students will be able to identify several aquatic organisms, and assess the relative environmental quality of a stream or pond based on indicators of pH, water temperature, dissolved oxygen, and the presence of various organisms.

Setting

Stream or slow-moving pond

Duration

One or two 40- to 60-minute periods; may take longer if done as a field study activity

Subject

Science, Biology, Chemistry

Skills

Application, Analysis, Classification, Comparing Similarities and Differences, Computation, Description, Discussion, Drawing, Evaluation, Generalization, Identification, Inference, Interpretation, Listing, Matching, Measuring, Observation, Prediction, Psychomotor Development, Reading, Research, Recognition, Synthesis, Writing (limited)

Grade Level

6-12

Vocabulary

indicator species   healthy environment   diversity
temperature   pH   dissolved oxygen

Background Information

Refer to Unit II, Section B-10.

Materials

- Identification guides such as *Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes* (New York, NY: Western Publishing Company, 1967) or *The New Field Book of Freshwater Life* (New York, NY: G.P. Putnam's Sons, 1966).
- Stream and Pond Organisms handout.
- Worksheets I and II.
- Sampling equipment, such as assorted containers, sieves, screens, plankton nets, seine nets, and dredge nets (a dredge net can be created by fastening a cloth bag to a rake).
- White enamel trays.
- Magnifying lenses (microscope optional).

Materials

(continued)

- Waterscope. (A waterscope can be fashioned by cutting a hole in the bottom of a wooden bucket, covering the hole with a piece of glass, and tacking down strips of wood to hold the glass in place. Seams can be sealed with aquarium cement.)
- Eyedroppers.
- Forceps.
- Water quality test kit (such as a Hydrion or Hach kit to test both pH and dissolved oxygen). A simple water quality kit can be obtained from scientific supply houses dealing with high school biology supplies. It may be possible to borrow a kit from a high school biology teacher.
- Thermometer.
- Meter sticks or tape measure.

Procedure

1. Select a sampling site. Try to find a small, fairly shallow, slow-moving stream or pond. Be alert to the safety of the students. If the stream is not a public site, be sure to gain permission to visit. Advise the students in advance to dress for the setting. Old shoes, shorts, or jeans would be best. Waders, if available, would also be useful.
2. Brief the students on habitat courtesies. Alert them to ways to minimize the potential for damaging the habitat and encourage care in their collection techniques. Emphasize that all the wildlife is to be returned to its habitat unharmed. You may choose whether or not to take some of the organisms back to school for further study. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!")
3. Start by observing the water using a waterscope, if you have one. Look for organisms on the surface and in the depths. Using the sampling equipment, have the students collect as many different forms of animal life as possible. Ask them to be alert to differing microhabitats near rocks, in riffles, and in eddies. Use forceps and eyedroppers to place the animals to be observed in the white trays. (The white background allows detail to be seen in the animals collected.) Keep an adequate amount of water in the trays and place them in a cool, shady spot. Change the water often to keep the animals cool. This is a good time for using microscopes if they were brought along.

Procedure *(continued)*

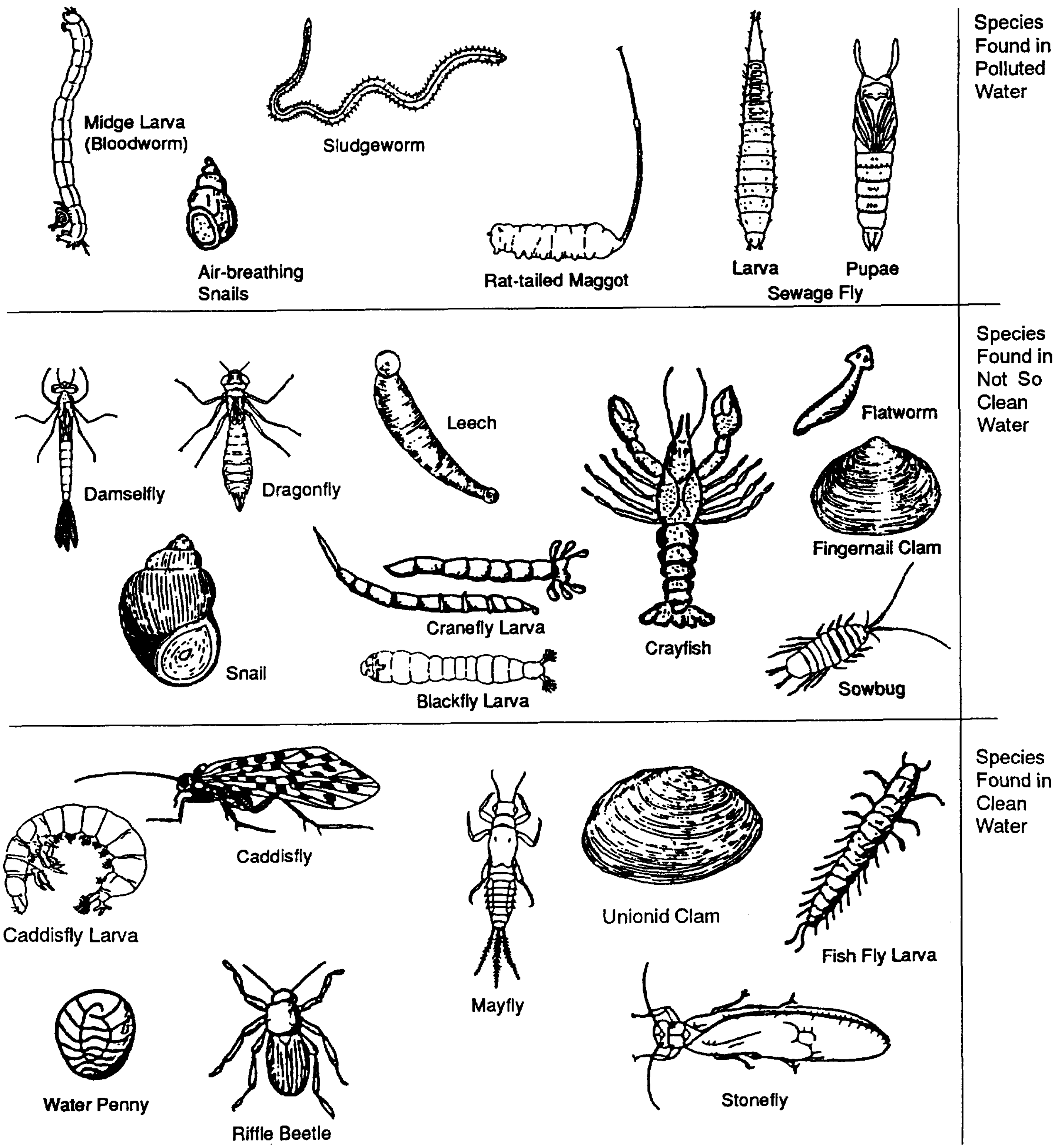
4. Using microscopes or magnifying lenses, have the students identify and draw the animals for Worksheet I. They should refer to the Stream and Pond Organisms handout. Ask them to fill in the number of each kind of organism found and describe the actual location where the animal was found. Once these observations are completed, carefully return the animals to their natural habitat. (If you choose to take some of the animals to the classroom, be sure there is adequate water that can be kept as cool as the natural setting. Petri dishes or any shallow transparent dish under an overhead projector makes for exciting viewing.)
5. Still in the outdoors, encourage students to discuss their observations. Were a lot of different organisms found? Introduce the concept of diversity of life—that is, a variety of different kinds of plants and animals is usually an indication of a healthy system.
6. Now test the water at the field site for other indicators of quality. Using the water quality kit, have students determine the pH of the water, the temperature of both the water and the air, and the amount of dissolved oxygen present (this may be difficult for younger students). These data should be recorded on Worksheet II.
7. Help the students understand that the pH, temperature, and dissolved oxygen content of a water body affect the diversity of life forms found there. Ask students whether they would expect the same variety of life in other locations.
8. Ideally, this activity should be repeated at other sites with different characteristics. The students should understand that biologists examine hundreds of sites in order to try to understand and predict what their evidence suggests is going on in natural systems. If another site is visited, it might be useful to divide the class into two groups with one half doing Worksheet I and the others doing Worksheet II. When each group is finished, they could come together and mutually predict what the other group had found.
9. Summarize the study by reemphasizing that the diversity of specific animals is a useful indicator of habitat quality, as well as an overall indicator of environmental quality.

Extension/ Evaluation

Draw pictures or create a mural of a healthy environment and an unhealthy environment.

Adapted with permission from: Western Regional Environmental Education Council, Aquatic Project Wild (Boulder, CO: WREEC, ©1987).

Stream and Pond Organisms



Worksheet I

Name of Organism	Sketch of Organism	Location	Number Found

Worksheet II

Observations

Water Temperature ____________ Dissolved O_2 ________________

Air Temperature ______________ Velocity ____________________

pH ________________________

Organisms Present

Human Use, Influence, and Impact on the Ohio River

Human Use, Influence, and Impact on the Ohio River

This unit will help students appreciate the importance of water in their own lives, and examine the effects, both positive and negative, of human activity on the Ohio River and its watershed. In *Section A,* students will explore the many uses of water and the Ohio River, including drinking, bathing, cleaning, transportation, industry, and recreation. They will build collages that show water uses, and models that demonstrate how water is stored and how it is distributed to homes and businesses. In the final activity in this section, students will have an opportunity to monitor their own daily use of water and consider ways to conserve this precious resource.

Section B delves into the many environmental problems facing the Ohio River Basin, many of which are human-induced. Such topics as accelerated soil erosion, flooding, river pollution, ground-water contamination, acid rain, and littering are explored with a variety of demonstrations and hands-on experiments that show both causes and effects.

In *Section C,* students will identify some of the signs that bodies of water are polluted, and view some of the micororganisms that may contaminate water. They will also observe the effects of purifying techniques, such as filtration, on dirty water and learn about the role of drinking water and wastewater treatment plants in keeping the Ohio River safe for human use.

In *Section D,* students will discuss the tradeoffs of economic use of the Ohio River versus concerns about the environment. The students will learn to make difficult decisions concerning resource use that balance the needs of many different segments of society. They will also investigate water pollution problems in their own community, learn about laws affecting pollution control and pollution cleanup, and suggest solutions that demonstrate their awareness of both economic and environmental costs and benefits.

A Our Relationship with Water

1 Water's Many Uses

Water is essential for survival (see Unit II, Section A). People use water on a daily basis and for many different functions. As a liquid, water serves as a beverage and assists in dozens of daily cleaning chores including showering and washing clothes. When water is in its solid state, it serves to keep things cool, in the form of ice cubes in a drink or ice in a freezer of frozen foods. People also use water to keep house plants alive, to make their gardens grow, and keep their lawns green. In addition, water allows people to enjoy such recreational activities as swimming, sailing, scuba diving, and canoeing.

On a larger scale, water is needed for industrial and agricultural uses. Many manufacturing processes, such as steel making and frozen foods packaging, require vast quantities of water. Farmers need water to irrigate their crops and to clean produce before selling it to distributors or to local markets. Water in the form of rivers, such as the Ohio River, also serves as a major corridor for shipping produce and manufactured goods and for commuting and tourism.

All living things need water to survive. (See Unit II, Section A-4.) In addition to the water needed for drinking (about 1½ quarts each day), each individual uses about 86 gallons of water daily for showering, flushing toilets, brushing teeth, washing hands, and other personal uses.

2 How People Get Their Water

The nation's drinking water comes from two different sources. About half comes from rivers, streams, and other forms of surface water. The United States has 2 million miles of streams and over 30 million acres of lakes and reservoirs that can serve as potential drinking water supplies.

Reservoirs are large, deep bodies of standing freshwater created by humans. They are often built behind dams to collect water running down from mountains in streams and rivers. Reservoirs also capture water from melting snow and rain that would otherwise be lost. Since the availability of water in different areas of the country varies, utilities store extra water in reservoirs so communities will not run out of water regardless of the amount of water they use. In addition to providing water for home use, water released from reservoirs can be used to generate hydroelectric power or to provide irrigation to grow crops on dry land.

The other half of the country's drinking water comes from ground water. Ground water supplies over 100 million people with their drinking water. The country withdraws about 90 billion gallons of ground water every day for all uses. This includes 12 billion gallons per day to supply the public with water.

Once water has been stored in reservoirs or tapped from groundwater sources, it needs to be treated to remove pollutants and distributed to its many users. (Section C of this unit will discuss the treatment process in detail.) The first human-constructed system for obtaining a supply of freshwater was through pumps from underground wells. In places like China, India, and other eastern countries, many wells were built thousands of years ago. The Roman Empire was one of the earliest civilizations to utilize a **distribution system**, which consisted of aqueducts or canals that brought water from mountains to cities. Although some of these aqueducts are still in use today, many innovations in distribution have been made since that time.

In 1652, Boston, Massachusetts, became the first American city to use pipes to extract water from a deep reservoir fed by springs and wells. This system allowed people to obtain as much water as they needed. In 1776, the first complete domestic water distribution system was set up. Stretching from Bethlehem, Pennsylvania, to Winston-Salem, North Carolina, this system carried water by pipes made of bored and fire-charred logs to many different cities.

Not until this century, however, did water become available to the extent that people take for granted today. Water distribution facilities exist all around the world transporting water to homes, businesses, and farms. This water is carried across many miles through durable pipes made of cast iron, steel, concrete, cement, or plastic. The water flows by gravitational force throughout the distribution system. As water travels through a distribution system, it is continuously diverted down different pathways, which lead to individual homes and businesses. The **circumference** of a pipe determines the quantity of water that can be contained in the pipe at any one time and determines, in part, the rate at which the water will travel through the pipe. As the distribution system expands to homes and businesses, the volume of water needed per home or business represents only a portion of the total volume leaving the treatment plant. Consequently, smaller pipes are used in these areas of the distribution system, whereas larger pipes are needed near the treatment plant.

3 Conservation of Water

A plentiful supply of water for drinking and washing is something that many Americans take for granted. By simply turning on the tap, people have access to gallons of drinkable water. Behind each gallon, however, is the unceasing effort of scientists, engineers, legislators, water plant operators, and regulatory officials who work to maintain a constant supply of this precious resource.

Household and other municipal water use accounts for about 9 percent of total water use in the United States. (See the table of Average Water Volumes Required for Typical Activities on p. 142, which accompanies the activity "Water Audit.") Because of the Earth's limited supply of usable freshwater (see Unit II, Section A-3) and the increasing expense of providing water of sufficient quality to home users, individuals and communities alike would be wise to employ water conservation measures.

One way to conserve water is to help preserve the quality of water in potential drinking water supplies such as lakes, rivers, and reservoirs. Ways that individuals can reduce nonpoint source pollution (described in Unit III, Section B-4) to these water bodies include:

- Keeping gutters and storm drains free of litter, pet wastes, leaves, and other debris.
- Applying lawn and garden chemicals sparingly and according to directions.
- Disposing of used oil, paints, and household chemicals properly and not in storm sewers or down drains.
- Controlling soil erosion in lawns and gardens by planting ground cover.

In addition, people should report any dumping of trash into lakes, rivers, or wetlands to the proper authorities.

Household members can also substantially reduce their daily consumption of water by keeping faucets in good repair; storing a supply of cold water for drinking in the refrigerator; installing water-saving toilets; taking shorter showers; and avoiding letting the water run while brushing teeth, washing hands, or doing dishes by hand. Water consumption outside the home can also be reduced by covering backyard pools to prevent evaporation, turning the hose off while washing the car and on only for rinsing, and watering the lawn and garden only as necessary and at night whenever possible. Wading pool water and rinse water from outdoor washing also can be recycled to water grass and shrubs.

Clean water is a valuable resource that must be used with care and consideration. Reducing water pollution and water consumption saves time and money in water treatment (see Unit III, Section C-3) and goes a long way toward ensuring a plentiful supply of water for the future.

Resources

Publications

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Resources *(continued)*

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The Valley. 1974. Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. Ohio River Valley water quality management programs (28 minutes). Junior to senior high school levels. Rental: $35.

Water and Life: A Delicate Balance. #IE-1139. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. The role of water in the human body (13 minutes). Film rental: $75.

Water for the City. #70194. Phoenix Films, Inc. (BFA Educational Media), 468 Park Avenue South, New York, NY 10016, 1-800-221-1274. Where cities get their water and how we get it to our homes (11 minutes). Primary and intermediate levels. Film availabe for sale or rental.

Water: We Can't Live Without It. National Wildlife Federation, 1400 16th St., NW, Washington, DC 20036-2266, 1-800-432-6564. Intermediate and advanced levels. Filmstrip or slide set. Cost: $26.95.

A

Activity

Water Use Collage

Objective

Students will gain an appreciation for the value of water in their own lives through brainstorming techniques and art.

Setting

Classroom

Duration

One 1-hour period

Subject

Art, Science, Social Studies

Skills

Small Group Work, Listing, Discussion, Media Construction, Brainstorming, Synthesis

Grade Level

K-2

Vocabulary

water

Background Information

Refer to Unit III, Section A-1.

Materials

- Magazines that can be used to make collages.
- Scissors.
- Paste or glue.
- Construction paper or other sturdy paper.

Procedure

1. Brainstorm with students to make a list of all the ways they use water.
2. Divide students into pairs or groups of three or four.
3. Have each team search through magazines and cut out pictures or words depicting or describing water use. You may ask each team to look for all types of water use or encourage teams to specialize in a particular area of water use, such as recreation or household use. One possible theme might be "how *I* used water today." Stress that students should be creative in distinguishing what activities we use water for.
4. Working in these same groupings, have students assemble collages demonstrating all areas of water use or their team's particular theme.
5. Ask students to think of a title that puts across the ideas in their collage.

Procedure *(continued)*

Display students' work on a bulletin board.

Extension/ Evaluation

From the list you made in Step 1 of the activity (and any additional uses), have students categorize the uses they make of water into essential and nonessential uses. For example, drinking water would be in the essential category; running under a sprinkler to cool off would be nonessential. Ask students if any of these uses potentially waste water. Help them to conclude that water is a precious resource that should not be wasted.

A

Activity

Where Does Our Water Come From?

Objective Students will construct a model to explore the function of a reservoir and how it works.

Setting Classroom

Duration 1 hour

Subject Art, Science, Social Studies

Skills Analysis, Application, Media Construction, Discussion, Observation, Experimenting, Psychomotor Development, Small Group Work

Grade Level 3-6 (This activity also can be done as a demonstration for younger grade levels.)

Vocabulary reservoir

Background Information Refer to Unit III, Section A-2.

Materials

- Clear plastic box for each group of students.
- Spray bottle.
- Pebbles.
- Soil.
- Sand.
- Leaves.
- Model of a Reservoir handout.

Procedure

1. Divide the class into teams of four to six students.
2. Have each team construct a model of a reservoir in a clean, clear plastic box. The teams should line the bottom of the box with small pebbles, and then layer sand, soil, and leaves on top (sloping the material downward toward the center of the box). (See the Model of a Reservoir handout.) Explain to students that each layer corresponds to a natural layer of earth found beneath a real reservoir.

Procedure *(continued)*

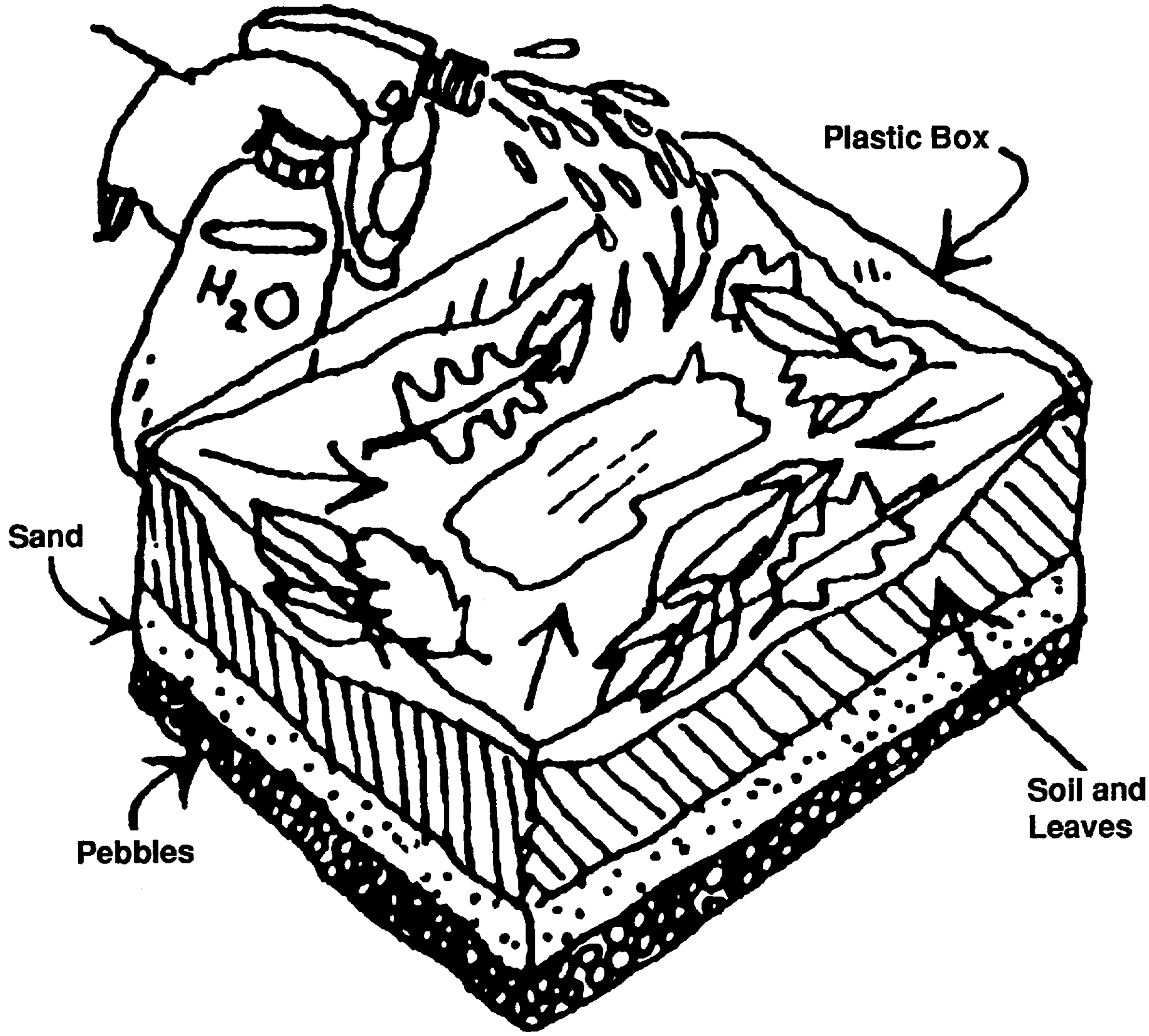
3. Have the students carefully spray water on the four corners of each model until the soil mixture is saturated and the water has seeped through to the open area. This becomes the reservoir.
4. Discuss the following questions with students:
   - What are the sources of water for a reservoir? (precipitation in the form of rain or snow)
   - How does water get into a reservoir? (It seeps over and through the soil above the reservoir.) You might also introduce the idea that many reservoirs are constructed by damming streams and rivers and thus have a continual supply of water flowing into them.
   - What contains or holds water in a real reservoir? (dams)
   - Would water in a reservoir undergo any kind of natural purification processes? If so, what might they be? (Natural filtration through leaves, grass, and soil; also some settling of soil and other impurities to the bottom of the reservoir.)

Extension/ Evaluation

Take a field trip to a nearby reservoir and observe where the water for the reservoir comes from. (Is it dammed from a stream or river, fed by underground springs, collected from precipitation, or all three?) Investigate which communities in the surrounding area use the reservoir for their drinking water and how it is distributed. If possible, invite a staff person from the local water resources authority to accompany you on the field trip to explain the workings of the reservoir.

Adapted with permission from: Water Wizards (Boston, MA: Massachusetts Water Resources Authority, 1983), pp. 10-14.

Model of a Reservoir



A

Activity

Model Distribution System

Objective
Students will learn how drinking water is delivered to a community by building a model water distribution system.

Setting
Classroom

Duration
1-hour

Subject
Art, Science, Social Studies

Skills
Analysis, Application, Discussion, Inference, Media Construction, Problem Solving, Measuring, Application

Grade Level
3-8

Vocabulary
distribution system circumference reservoir

Background Information
Refer to Unit III, Section A-2.

Materials

- Large piece of paper or cardboard.
- Paper towel tubes.
- Different sizes of pasta (linguini, spaghetti, ziti, manicotti).
- Glue.

Procedure

1. Discuss the concepts of reservoirs and distribution systems with students. You might discuss some of the earliest distribution systems designed by humans.
2. Place the sheet of cardboard or paper on a large table and have students gather around it.
3. Draw and label a reservoir or other water source at one end. Ask students to help you fill in houses, farms, factories, stores, schools, and any other businesses that need water.
4. Using the paper towel tubes and the pasta create a community pipe system that distributes water to all of the "buildings" on your map. Allow students to assist you in choosing appropriate "pipe" sizes, laying them out, and glueing them down on the sheet. Discuss with students as you work that the circumference of the pipe decreases as the distribution system spreads out into the community, because the amount of water the pipe needs to hold decreases.

Procedure *(continued)*

5. In a concluding discussion, ask students the following questions:
   - What would happen if new homes or businesses are built in this community?
   - How would this growth affect the water supply?
   - What possible actions might be taken? (Increase the capacity of the reservoir, get water from another source, or decrease the supply of water to each existing home and business.)

Extension/ Evaluation

Have students speculate about what happens to the water after it leaves the homes and businesses where it has been used. Where might this water eventually end up? What potential problems might it create? As a class, have students write a letter to the water authority in your community or invite a representative to come speak about where water goes once it has been used and what happens to it.

Adapted with permission from: Water Wizards (Boston, MA: Massachusetts Water Resources Authority, 1983), pp. 10-14.

A

Activity

Water Audit

Objective

Students will learn to value water by analyzing their own consumption of water and suggesting ways to conserve this resource.

Setting

Classroom and home

Duration

Five days, including two 30- to 40-minute class periods

Subject

Economics, Mathematics, Science

Skills

Analysis, Application, Computation, Discussion, Estimation, Interpretation, Recording Data, Synthesis

Grade Level

7-12

Vocabulary

conservation

Background Information

Refer to Unit III, Section A-3.

Materials

- Average Water Volumes Required for Typical Activities handout.
- Water Use Analysis handout.

Procedure

1. Begin the activity by asking students to estimate how much water it takes to perform the following activities: taking a shower, washing your hands, washing a car, running the dishwasher, brushing your teeth. Have them write their estimates on a piece of paper.
2. Write some of the students' estimates on the board. Then pass out the Average Water Volumes Required for Typical Activities handout and see how close students came to the correct amounts.
3. Ask students to keep a diary of water use in their homes for 3 days. Students should use the Water Use Analysis handout, adding any activities for which they use water that are not listed.
4. On the fourth day, have students, in class, perform the following computations:
   - Estimate the total amount of water your household used in the 3 days. Give your answer in gallons.

Procedure *(continued)*

- On average, how much did each member of your household use during the 3 days. Give your answer in gallons per person per day.
- Compare the daily volume of water used per person in your household to the average volume used per person per day in the United States (approximately 86 gallons). What reasons can you offer to explain the difference?

5. In a concluding discussion, ask students if they were surprised at the amount of water they used. What had they expected?

Extension/ Evaluation

Ask students to think of ways in which their households could reduce their water consumption. Make a list on the board or have students make their own lists. (Examples might be taking shorter showers, waiting until the dishwasher is full before running it, turning the water off while brushing teeth instead of letting it run.) Then have students repeat their audits and see if they can substantially reduce their water use over the next 3-day period, employing some of these conservation measures. Have them perform the same calculations at the conclusion of the activity, compare results, and discuss.

To sharpen students' computational skills, have them convert the values they obtained in this activity into liters (or have them give values in both gallons and liters initially).

Adapted with permission from: American Chemical Society,. Chemistry in the Community (Dubuque, IA: Kendall/Hunt Publishing Company, 1988), pp. 11, 16-17.

Average Water Volumes Required for Typical Activities

Use	Volume of Water gallons (liters)
Tub Bath	35 gal (130 L)
Shower (per min)	5 gal (19 L)
Hand Washing	20 gal (76 L)
Tooth Brushing	2 gal (7.6 L)
Washing Machine Low Setting High Setting	 19 gal (72 L) 45 gal (170 L)
Dish Washing By Hand By Machine	 10 gal (40 L) 12 gal (46 L)
Toilet Flushing	3 gal (11 L)

Water Use Analysis

Data Table	Days 1	2	3
Number of Persons in Family			
Number of Baths			
Number of Showers Length of Each in Minutes			
Number of Washing Machine Loads Low Setting High Setting			
Dish Washing Number of Times by Hand Number of Times by Dishwasher			
Number of Toilet Flushes			
Other Uses and Number of Each Cooking Drinking Making Juice and Coffee			

B The Impact of Residential, Industrial, and Agricultural Use on the Ohio River

1 Erosion and Erosion Control

The Ohio River Basin is part of the Eastern Woodlands Region. Before intense human development of the area, the Ohio River Basin was covered primarily with deciduous forests. The agricultural development that occurred in the Ohio River Basin resulted in forest areas being cleared, exposing the soil to wind and water, which caused soil erosion.

Erosion results from natural environmental forces, such as wind, rain, and glacial movement. Although erosion is a natural phenomenon, it can be intensified by human activities. One human activity that significantly intensifies erosion is the removal of vegetation, which exposes soil to environmental forces. Vegetation reduces erosion because the roots of trees and other plants tend to hold soil in place. In addition, leaves of trees and other plants, both on branches and on the ground, reduce the intensity of environmental forces. For example, leaves act as windbreaks, minimizing the ability of wind to pick up and carry away soil particles. Leaves also break up rain drops, slowing their speed and reducing the size with which they hit the ground. In turn, this reduces the ability of rain to erode soil.

Clearing woodlands or meadows for cropland exposes soil to the forces of wind and water. Tilling also disturbs the soil, loosening particles that can be more easily carried away by wind and water. Overgrazing of rangeland by livestock, which can strip areas of ground cover needed to keep soil particles in place, also accelerates erosion. Some logging operations intensify erosion by stripping trees from an area without replanting. Urban development also can accelerate erosion. Activities such as bulldozing not only expose soil to natural forces, but can also loosen soil particles.

Soil erosion has several negative consequences. First, it results in the loss of topsoil, which contains organic matter that provides nutrients for plant growth. Because it takes natural processes 500 to 1,000 years to create one inch of topsoil, this valuable resource is essentially nonrenewable. Topsoil loss is particularly devastating for farmers, as it can lower crop yields, increase fertilizer requirements, reduce the soil's capacity to hold water, complicate tillage practices, and generally increase costs of farm operation. Total costs to farmers alone for erosion damage in the United States is estimated to be in the billions of dollars each year. Erosion damage also costs many other people money as well.

Soil erosion is also one of the major causes of water quality problems in this country. Soil particles that enter water bodies cloud the water, reducing its aesthetic value and potentially clogging the gills of fish and other organisms, such as clams and mussels. Sediments also can cover and even kill bottom-dwelling organisms in the aquatic environment, and may destroy fish spawning areas. In addition, soil particles often carry fertilizers, which can cause excessive algae growth, and pesticides, which can be toxic to aquatic organisms. Soil particles can enter rivers and harbors in such quantities that navigation is restricted and costly dredging of river channels may become necessary. Millions of tax dollars per year are spent to dredge sediments from navigational rivers and harbors. In addition, sediments decrease the capacity of reservoirs and other waterways, increasing flooding hazards and reducing the water supply available in times of drought. When suspended in water, sediments can make water unsafe for drinking and can significantly increase the costs of drinking water treatment.

Erosion control can be used to minimize soil erosion. For example, many farmers currently leave crop residues or other plant material on the soil surface between growing seasons to reduce soil exposure and minimize erosion. Similarly, during construction projects, soil can be covered to reduce its exposure to environmental forces. Farmers also can utilize tilling practices that reduce soil disturbance.

2 Human Development and Flooding

When precipitation falls in natural terrestrial environments, most of it generally **infiltrates** the soil. The water that does not immediately sink into the ground, but instead travels over the surface, is known as **runoff**.

The **development** of residential communities, industrial centers, and urban areas produces expanses of land covered by impervious surfaces (such as pavement and rooftops), which can cause significant increases in surface water runoff. These impervious surfaces shed water and prevent soil infiltration. A U.S. Geological Survey study indicated that urban runoff in an area can be more than four times greater than the runoff that occurs in the area prior to urbanization.

Urbanization can also increase the threat of flooding. When rainfall is light and of short duration, runoff will travel relatively short distances before it is absorbed by a permeable surface. When rainfall is heavy or of relatively long duration, however, the soil becomes saturated and cannot absorb additional water. The greater the percentage of ground covered by impervious surfaces, the more quickly this saturation occurs. Once land is saturated, runoff will travel greater distances, generally until it reaches a river, lake, or some other surface water body. When great quantities of runoff enter surface water bodies, flooding can result.

Development in the Ohio River Valley over the last hundred years has resulted in increased runoff and a greater threat of flooding. The steep hillsides, which are commonly found in the upper reaches of the Ohio River (but are also found in lower reaches), are especially prone to runoff and erosion. Severe floods in 1913 and 1937 and high unemployment during the Great Depression resulted in strong governmental reforestation programs for these slopes. At the same time, dams were built for flood control and recreation. Controversy still exists over which method, dams or reforestation, is best for flood control.

3 Locks and Dams for Navigation

In its natural state, the Ohio River was difficult to navigate. Floods in the spring caused treacherous conditions and the water level was often too low for safe and easy passage during other times of the year. In the early 1800s, U.S. government engineers cleared rocks and other obstacles from the river and built a canal near the falls of the Ohio River at Louisville. However, additional measures were necessary to make the river a reliable shipping channel. So, in 1875, work began on a series of more than 50 locks and dams. Locks and dams are constructed along a waterway to maintain a minimum depth, which is needed to make the river or stream a useful transportation corridor. Dams are structures that impound water that would naturally flow along the river.

Locks are structures that allow boats to be raised or lowered. These structures are enclosed by gates, or dams, that can hold water. When boats enter the lock, water is either released from the lock, or allowed to enter the lock, until the water level in the lock is the same as the water level in front of the lock. When this level is attained, the gate at the end of the lock is opened and the boat is allowed to travel on without being subject to a steep incline or descent.

The first stage of Ohio River lock and dam construction was completed in 1929 and maintained the depth of the river channel at a minimum of 9 feet to allow for easy passage. After this work was completed, the government began to build even larger locks and dams. This improvement program continues today.

Locks and dams can affect the environment in several ways. First, they slow the natural velocity of the river so that organisms that were adapted to natural river flows are replaced by organisms that prefer more slowly moving water bodies. Secondly, dams trap sediments that would otherwise continue to flow down the river or stream. The rivers or streams, therefore, may require significant dredging and maintenance to keep sediments from hampering transportation. In addition, nutrients often are trapped behind the dams, reducing the fertility of areas at the end of the river and resulting in a reduction in plants and animals in these typically productive areas. Sediments also help to construct deposits, or deltas, at the river mouth. If the sediments are trapped behind dams, these delta areas will shrink.

4 River Pollution

In the United States, more than 370,000 miles of streams and rivers are contaminated. In general, water pollution is caused by four major sources:

1. Nonpoint
2. Municipal
3. Industrial
4. Dredging

Nonpoint sources. Nonpoint sources are the largest contributors to river and stream pollution in the United States and account for 65 percent of contamination. Nonpoint source pollution does not come from a specific location but rather results from land uses such as agriculture, mining, forestry, and urban activity. An example of a nonpoint source is runoff from rainwater washing over farmlands and carrying topsoil contaminated with pesticides and fertilizers to nearby streams or ponds. Runoff from urban areas, mining, forestry operations, and construction activities are other examples of nonpoint sources of pollution. Sediment is the primary water pollutant from nonpoint sources (as discussed in Unit III, Section B-1). Runoff may also contain oil, gasoline, pesticides, nutrients, heavy metals, other toxic substances, bacteria, and viruses.

Nonpoint water pollution can be minimized by reducing soil erosion (mechanisms for reducing soil erosion are presented in Unit III, Section B-1). In addition, water bodies can be surrounded by buffers of grass or woodlands that can absorb water and prevent sediments and other contaminants from reaching the water.

Municipal sources. Municipal sources cause almost 20 percent of river and stream contamination. Municipal sources of pollution include municipal wastewater and stormwater runoff that enters the sewer system. Municipal wastewater is the water that flows from residential or business sewers into the municipal wastewater treatment system. This water contains human wastes and associated organic materials, nutrients, bacteria, and viruses; toxic substances such as household cleaners, crankcase oil, paint, and pesticides; food wastes from garbage disposals; and other solids. The municipal wastewater is transported from homes and businesses to the municipal wastewater treatment facility through a series of pipes and sewers. After treatment to remove contaminants, water is released into a water body, such as a river, stream, or lake (refer to Unit III, Section C-2). Although most contaminants are removed during wastewater treatment, some contamination may be released.

Stormwater runoff is water that flows from the land into municipal sewer systems, or directly into water bodies, during periods of precipitation. Water runoff can pick up large quantities of contaminants, such as road oil and pesticides, as it runs over lawns, through gutters, and along streets. In some cases, this stormwater enters the wastewater sewer system and is transported to wastewater treatment facilities where the water is treated to remove contaminants. Sometimes during periods of heavy precipitation, the system cannot handle the combined flow and the water flows directly into water bodies, causing water pollution. Efforts are underway to separate wastewater and stormwater systems and, eventually, to ensure both will receive complete treatement.

Water pollution associated with municipal wastewater can be significantly reduced by properly constructing and maintaining household and municipal wastewater systems. Technology in recent years has greatly reduced pollution caused by wastewater treatment facilities. Problems associated with stormwater runoff can be minimized by constructing wastewater treatment facilities with extremely large capacities to handle water generated during large storms, or storage ponds to hold the water until it can be treated. Finally, stormwater and wastewater flows can be separated to ensure that stormwater and wastewater are not mixed.

Industrial sources. Industrial sources of pollution are also significant and cause almost 10 percent of all stream and river contamination. Industrial sources include chemical discharges from industrial plants, which are either released directly into a water body or into the air. Pollutants in the air can eventually fall back to the ground or into a water body through precipitation. Many of these chemicals are toxic and can harm the health of humans, wildlife, and plants.

Several federal and state laws limit the quantity of chemicals that can be released into a water body by industrial plants, and, in some cases, require that certain pollution control measures be used. Pollution control technologies are used to treat contaminated water before it is released. They also can be used to remove or reduce many contaminants from the gases released into the air through industrial smokestacks.

Dredging. Dredging also causes water pollution. When waterways become too shallow or narrow for navigational purposes, some of their bottom sediments may be dredged and removed. Dredging stirs up bottom sediments that often contain contaminants that have been concentrated over time. Stirred-up sediments and contaminants can cause significant pollution problems in rivers.

Pollution problems associated with dredging river and stream channels are extremely difficult to address. Fine-meshed screens can be constructed around dredging activities to filter out sediments, but these methods are not completely effective and sediments and other contaminants are routinely released. In general, the only effective way to minimize dredging pollution is to reduce both the frequency with which dredging occurs and the contamination of bottom sediments. Reduction of soil erosion will minimize the quantity of sediments that enters waterways, thus limiting the number of times dredging will need to be conducted. Control of point and nonpoint pollution will reduce contamination of the bottom sediments of waterways, minimizing the quantity of contaminants that are stirred up when dredging is necessary.

5 Ground-Water Contamination

Ground water is water that exists in spaces in rock, gravel, and soil below the surface of the ground. Ground water accumulates in formations called **aquifers** when rainfall and surface water percolate through the ground. (For more information about ground water and its importance, see Unit II, Section A-2 and Unit III, Section A-2.)

There are two major environmental problems that can affect ground water. The first is overuse of ground-water supplies. In general, water filters down into aquifers at very slow rates. This percolation of water into the aquifer is called recharge. When water is pumped from the aquifer at faster rates than it is recharged, the amount of water in the aquifer is reduced. This means that less water will be available for future use. In addition, the water takes up space in the aquifer. When the water is removed, void spaces open up and rock or sediments around these void spaces sometimes collapse. With the loss of void spaces, the aquifer's ability to hold water is reduced, and future recharge of the aquifer is more difficult. In addition, the collapse of void spaces can cause the ground to sink, a process known as subsidence. Roads, buildings, and natural features can be damaged when subsidence occurs.

The second major environmental problem is contamination. Ground water is generally contaminated when chemicals and other pollutants filter down with water into the aquifer. The sources of these contaminants include runoff from agricultural and residential areas containing pesticides, herbicides, and fertilizers; runoff from roads containing oil, gasoline, and other chemicals; release of contaminants from landfills and other storage facilities; septic tank discharge; and sewer leakage. In some cases, contaminants are released directly into the aquifer from leakage or discharge from underground wells that are used to dispose of wastes. Once ground water is polluted, it is very difficult and costly to treat.

6 Power Plants in the Ohio River Valley and Their Impact on Acid Rain

Many power plants are needed to supply electrical energy to the population and industrial centers of the Ohio River Valley. In fact, the Ohio River is known for the large number of **coal-fired power plants** along its shores. Coal-fired power plants were constructed largely because coal could be easily transported in barges along the Ohio River. In addition, river water could be used for power plant cooling towers. This large number of coal-fired power plants, however, has caused environmental problems on a local, regional, and even international scale.

Fossil fuel-fired power plants (those that burn coal, oil, or gas), as well as cars and some other industrial and municipal sources, release **sulfur dioxide** and **nitrogen oxide** into the air, which can cause **acid deposition**, also known as **acid rain**. Acid deposition occurs when sulfur dioxide and nitrogen oxide are mixed with oxygen and water in the atmosphere and chemically transformed into acid compounds. These compounds may return to the earth in rain, snow, fog, or dust.

Scientists believe that acid deposition is damaging lakes, streams, rivers, forests, crops, buildings, and structures, and has the potential to affect human health. As water bodies acidify even slightly (i.e., the pH falls from 7 to 6), the diversity of species declines. (See Unit II, Section B-2 for more information on pH.) As the pH drops to 5, large numbers of species are eliminated. When the pH falls below 4.7, almost all of the plants and animals that form the base of the food chain are killed and birds, fish, amphibians, and mammals that depend upon these food sources are consequently affected.

On a global scale, thousands of lakes are threatened by acid deposition. In North America, lakes in the Adirondack region of New York and Ontario, Canada, are especially damaged by acid deposition. There is a clear link between activity in the Ohio River Valley and the acid deposition problem in New York and Ontario. In order to meet Clean Air Act standards, many coal-burning power plants constructed tall smokestacks in the 1970s. This was meant to allow chemicals to disperse in upper air levels where they would not be harmful to humans. However, prevailing weather patterns caused the emissions to be swept from the Ohio River Valley toward New England and into Canada.

The productivity of forests and the fertility of soils are also threatened by acid deposition. A 1980 study on emissions from coal-fired power plants in the Ohio River Basin concluded that acid deposition was causing essential nutrients and minerals to be leached (i.e., dissolved by the acidic water and carried away) from the soil, reducing the forest growth in the Basin by an estimated 5 percent per year. Acidity can also cause the leaching of toxic metals from soil or rock, raising the levels of these metals in surrounding water supplies and aquatic ecosystems. Laboratory experiments have indicated that acidity can make plants more vulnerable to infection and lessen their resistance to insect predation.

Acid deposition also significantly affects buildings and other man-made structures. For example, acid rain will react with calcite in marble objects, forming gypsum. Gypsum is a very soft material and can easily be corroded.

Several organizations, including the National Audubon Society and the National Atmospheric Deposition Program, are currently monitoring acid concentrations in precipitation throughout the country. Ultimately, this information can be used to target areas of concern and to monitor the effects of acid deposition control measures.

One method of controlling acid deposition is to put "scrubbers" on power plant smokestacks, which remove sulfur dioxide and nitrogen oxides. This technology can help to reduce the problem, but it is costly and only partially effective. A better way to minimize acid deposition is to conserve energy.

The first legislation in U.S. history to control acid rain was passed as part of the 1990 Clean Air Act Amendments. The law requires, over time, that virtually all fossil fuel-fired utility plants significantly reduce their emissions of sulfur dioxide and nitrogen oxide. It also provides incentives for utilities to conserve energy and use renewable energy rather than fossil fuels. The legislation should go a long way toward solving the acid rain problem.

7 Problems with Litter

Litter consists of objects that have been improperly discarded. Most litter accumulates as a result of careless or negligent actions by people, such as throwing unwanted items from cars or boats, or leaving garbage after picnicking. Litter can also accumulate, however, when it is blown from landfills, garbage trucks, or garbage barges.

Litter has several negative environmental effects, the most obvious being the aesthetic degradation of outdoor settings. Beer cans or hamburger wrappers strewn along the side of the road or along a river are unsightly. Another problem is potential human health effects, such as people cutting themselves on broken glass or rusted cans, or touching tissues and other materials that have the potential to carry bacterial contamination.

Finally, litter can be life-threatening to wildlife. Fish, birds, and other animals (such as turtles) can become entangled in plastic nets, line, and six-pack rings. These entanglements can cause painful lacerations, suffocation, or drowning. They also can hamper an animal's ability to move freely and to obtain food. Birds and turtles also may ingest plastic debris, which can become lodged in their intestines, hampering their ability to digest food. Some of these animals can ultimately starve to death.

Litter can be reduced when people are educated on the negative effects of disposing of materials in improper settings. In addition, programs to recycle articles that are littered, such as plastic bottles and newspapers, can also reduce littering. Finally, making articles that are frequently littered **degradable** (i.e., capable of being broken down into smaller pieces by the action of sun, water, or microorganisms) may minimize the effect these articles have on wildlife when they are littered.

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Resources *(continued)*

Western Regional Environmental Education Council. 1987. Aquatic Project Wild: Aquatic Education Activity Guide. Boulder, CO: WREEC.

Western Regional Environmental Education Council. Project Wild. 1986. Boulder, CO: WREEC.

Audiovisual Programs

Acid Rain. Films for the Humanities & Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. This film covers the history of acid rain and the problems that it poses (20 minutes). Rental fee: $75.

Acid Rain: A Neglected Responsibility. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Discusses the chemical and meteorological phenomena that contribute to acid precipitation, the reaction of living organisms, secondary processes that compound the problem, and the effects on humans (filmstrip or video).

Biological Studies of River Pollution. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Shows the effects of pollution on wildlife in rivers and streams (slide show). Cost: $79.95.

Clean Water. Films for the Humanities & Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. This film looks at the unsuspected environmental and health problems people unwittingly create at home and offers suggestions on how to minimize these problems (29 minutes).

Conservation Down on the Farm. 1981. Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. Describes best management practices for agriculture to prevent erosion and nonpoint source pollution (20 minutes). Fee: $40.

Flatboat to Towboat. Reserve through the Cincinnati Public Library, Cincinnati, OH. Call 513-369-6900 for borrowing procedures.

Ground Water: America's Buried Treasure. National Well Water Association, 6375 Riverside Drive, Dublin, OH 43017, 614-761-1711 ext. 549. Emphasizes the dangers of ground-water pollution caused by man.

Resources *(continued)*

Ohio River: Industry and Transportation. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 212-684-5910. In this film, cameras travel along the Ohio River from Pittsburgh, Pennsylvania, to Cairo, Illinois, and show how locks and dams are used for transportation. It also shows the pollution problems that have resulted (16 minutes). Junior high school level.

Problems of Conservation: Acid Rain. Encyclopaedia Britannica Educational Corporation, 310 South Michigan Avenue, Chicago, IL 60604, 1-800-554-9862. Investigates the causes of acid rain and discusses ways to alleviate the threat of acid rain to the environment (18 minutes). Junior to senior high school levels.

Problems of Conservation: Water. Encyclopaedia Britannica Educational Corporation, 310 South Michigan Avenue, Chicago, IL 60604, 1-800-554-9862. This film provides examples of water pollution problems and shows how dirty water can be treated and returned to its pure state (16 minutes). Junior to senior high school levels.

The Underlying Threat. Bullfrog Films, Oley, PA 19547, 1-800-543-FROG. Examines some of the causes and consequences of groundwater pollution (48 minutes). Rental fee: $75. Junior to senior high school levels.

Water Pollution. Educational Images, Ltd., P.O. Box 3456, West Side, Elmira, NY 14905, 1-800-527-4264. Surveys factors contributing to the contamination of our water supply (filmstrip, slide show). Cost: $24.95.

Water Pollution: A First Film. Phoenix Films, Inc., 468 Park Avenue South, New York, NY 10016, 212-684-5910. Describes the water cycle, the human role in the water cycle, and the problems of water pollution (12 minutes). Primary to junior high school levels.

B

Activity

Losing Soil

Objective

Students will demonstrate by building models how soil erosion occurs and what factors accelerate the process.

Setting

Preferably outdoors

Duration

One 1-hour period

Subject

Science

Skills

Observation, Analysis, Discussion, Experimenting, Media Construction, Comparing Similarities and Differences, Description, Application

Grade Level

1-6

Vocabulary

soil erosion   erosion control

Background Information

Refer to Unit III, Section B-1.

Materials

- A minimum of two pans or trays (e.g., aluminum cake pans).
- A garden trowel or stick.
- Soil (preferably sandy soil).
- Water.
- Watering can or pitcher.
- Mulch, leaves, and/or grass seed.
- A brick or block.

Procedure

Part 1 - Effect of Slope on Soil Erosion

1. Fill two identical pans (or trays) with soil. Pack down the soil and level it off with the edge of the pans.
2. Place pans on a flat surface, preferably outdoors on a concrete walk. Leave one pan flat. Tilt the other pan by propping one end up on a brick or block.
3. Sprinkle both pans equally with a watering can or pitcher.
4. Repeat Step 1 and then tilt one pan gently and the other steeply. Repeat Step 3.

Procedure *(continued)*

Discuss with students what soil erosion is and how it can be caused by rainfall. Ask students how the slope of the pan affected the amount of soil that was washed out of the pan. Ask students why steeper slopes increase rates of erosion.

Part 2 - Effect of Ground Cover on Soil Erosion

1. Fill two identical pans (or trays) with soil. Pack down the soil and level it off with the edge of the pans.
2. Cover one pan with mulch or leaves. (Another alternative is to plant one pan with grass or another ground cover, but this will require several weeks of advanced preparation.) Leave the other pan bare.
3. Place pans on a flat surface, preferably outdoors on a concrete walk. Tilt both pans at equal angles.
4. Sprinkle both pans equally with a watering can or pitcher.

Ask students how ground cover affects soil erosion. Discuss why ground cover minimizes erosion.

Part 3 - Effect of Furrow Orientation on Soil Erosion

1. Fill two identical pans (or trays) with soil. Pack down the soil and level it off with the edge of the pans.
2. Place pans on a flat surface, preferably outdoors on a concrete walk. Tilt both pans at equal angles.
3. "Plow" the soil with the garden trowel or stick. "Plow" so that the furrows run up and down the slope in one pan and across the slope in the other.
4. Sprinkle both pans equally with a watering can or pitcher.

Ask students how furrow orientation affects soil erosion. Ask why less erosion occurred when the furrows ran across the slope.

Discuss with students the types of farming or development practices that can be expected to accelerate erosion. Students should be able to explain that development on slopes, removal of ground cover, development on bare fields, and plowing up and down slopes increase soil erosion problems. Then discuss methods to minimize soil erosion, such as maintaining ground cover, plowing across slopes, and minimizing development on steep grades. Finally, the negative effects of soil erosion (e.g., sedimentation in water bodies, the loss of valuable topsoil), and the benefits of minimizing soil loss should be discussed.

Extension/ Evaluation

Visit a farm to observe erosion control practices or invite a local farmer to come in and talk to the class about soil erosion. Films or filmstrips on soil erosion can also be shown (consult Unit III, Section B, Resources).

B

Activity

Sinking In: Development and Flooding

Objective Students will observe the effects of runoff and infer how development increases the threat of flooding.

Setting Outdoors, in an area with paved and grass-covered surfaces

Duration One 1-hour period

Subject Science, Social Studies

Skills Analysis, Comparing Similarities and Differences, Description, Observation, Discussion, Application, Experimenting, Inference

Grade Level K-4

Vocabulary runoff development infiltrate

Background Information Refer to Unit III, Section B-2.

Materials

- A hose.

Procedure

1. On the grass-covered surface, turn on the hose and let the water run for a couple of minutes. Have the students watch the water disappear. Ask them where the water has gone.
2. On the paved area, turn on the hose and let the water run for a couple of minutes. Have students follow the water to see where it runs. Ask why the water did not sink in. Ask where the water goes.
3. Have the students explore the area to find surfaces where water would and would not sink in.

Discuss with students which surfaces caused the water to run off and which surfaces allowed the water to sink in. Have them make the link between manmade surfaces (such as pavement and rooftops) and water runoff. Ask them what will happen to rainwater as more areas are developed. Ask them if they think flooding occurs more frequently in undeveloped areas, or in highly developed areas of the Ohio River Valley.

Extension/ Evaluation

Ask students to conduct the hose experiment at home and find areas where water runs off and areas where it sinks in. Have students draw a map of their yards, indicating which areas absorb water and which areas allow water to run off.

B

Activity

Ohio River Navigation Locks and Dams

Objective

Students will use the number line concept to illustrate the large number of locks and dams found along the Ohio River and to consider the impact that locks and dams have on the surrounding environment.

Setting

Classroom

Duration

One 1-hour period

Subject

Mathematics, Social Studies

Skills

Analysis, Application, Computation, Discussion, Identification, Map Reading

Grade Level

4-6

Vocabulary

dams locks

Background Information

Refer to Unit III, Section B-3.

Materials

- Copies of the Ohio River Navigation Locks and Dams map.

Procedure

1. Review the concept of a number line.
2. Distribute an Ohio River Navigation Locks and Dams map handout to each student.
3. Explain to students that each slash mark represents a navigational lock or dam located along the Ohio River, and explain how locks and dams work. Suggest that the map can be considered a "squiggly" number line.
4. Explain that the list given on the map contains the names of the locks and dams found along the Ohio River. Also explain that the numbers given after each name represent the number of miles along the river that each lock or dam is located from the convergence of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania, the source of the Ohio River.

Procedure *(continued)*

5. Have students use the list with the mileage numbers to name the locks and dams on the map. The students could begin by rewriting the list from least to greatest distance from the Ohio River's source.

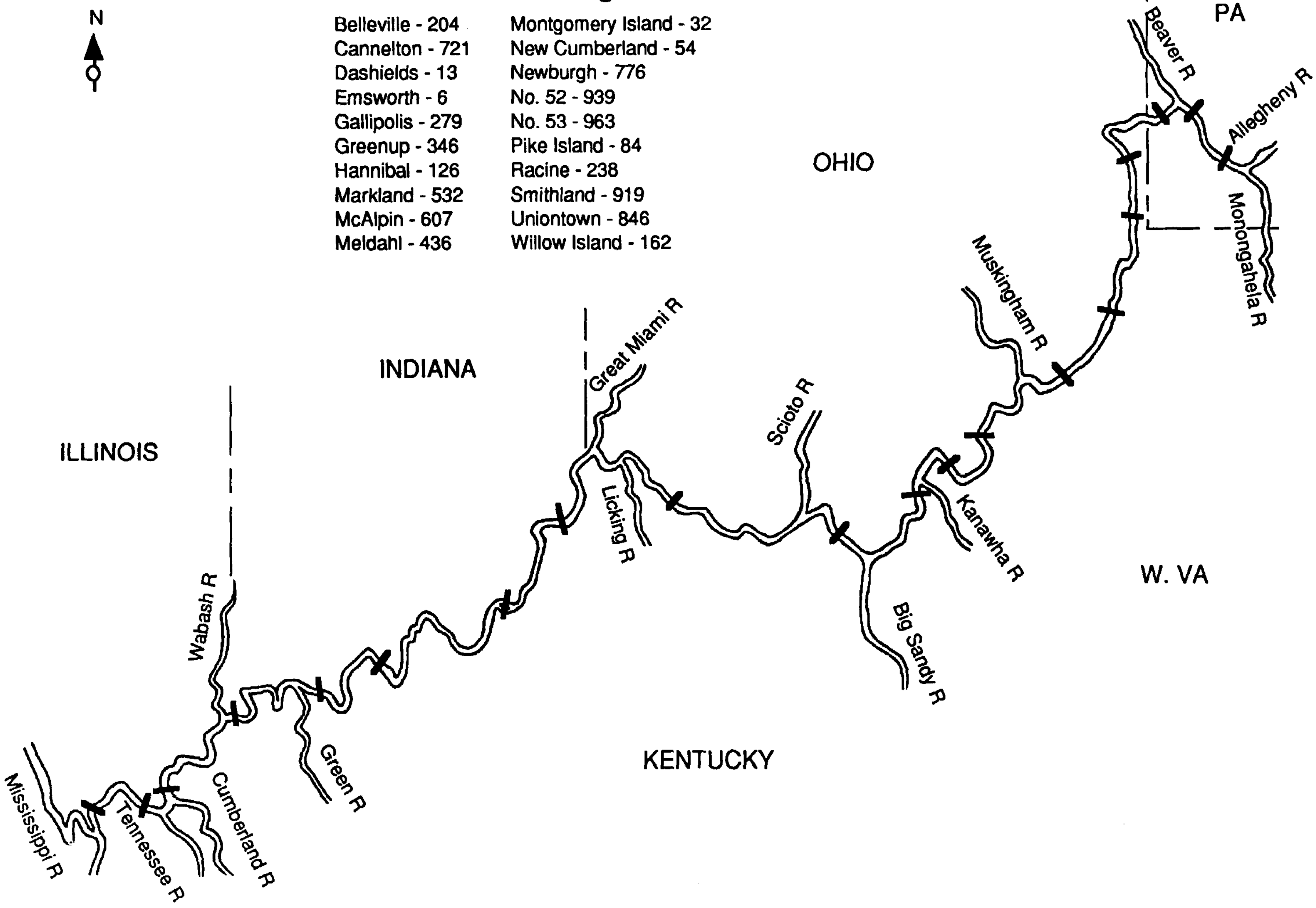
6. Ask the students how many locks and dams can be found along this stretch of the Ohio River. Ask what the distance is between the closest of the locks and dams. Ask what the distance is between the first and the last of the locks and dams. If the students have learned how to compute averages, ask them what the average distance is between the locks and dams along the Ohio River.

Extension/ Evaluation

Discuss with students the impact that locks and dams can have on the surrounding environment, emphasizing how they alter the flow and change the water level along different sections of the river.

Take a field trip to the closest lock or dam located on the map, or suggest that students visit one of them on their own. Have students note the difference in velocity between the water flowing behind the lock or dam and in front of it. Have them observe the differences in plant life and animal life in front of and behind the lock or dam. Discuss the impact the lock or dam is having on the area surrounding it and the wildlife in that area. In addition, a film can be shown on transportation locks and dams (consult Unit III, Section B, Resources).

Ohio River Navigation Locks and Dams



B

Activity

Who Pollutes the River?

Objective

Students exercise problem solving by examining potential polluters and exploring strategies for minimizing pollution.

Setting

Classroom

Duration

One 1-hour period (with one 1-hour period followup, if desired)

Subject

Language Arts, Science, Social Studies

Skills

Analysis, Description, Discussion, Problem Solving, Inference, Reading

Grade Level

1-3 if profiles are read aloud, 4-6 if students read profiles individually

Vocabulary

water pollution

Background Information

Refer to Unit III, Section B-4.

Materials

- Copies of the "Who Pollutes?" handout.

Procedure

1. Discuss with students what pollution is and ways that the Ohio River can become polluted.
2. Distribute copies of the "Who Pollutes?" handout, and have students read the handout. (For grades 1-3, the profiles can be read aloud by the teacher.)
3. After students read handouts, discuss each person listed individually. Have students determine which individuals would be guilty of pollution. Ask students what kind of pollution these individuals would generate. This discussion should emphasize that many activities not commonly considered to be environmentally harmful do, in fact, cause pollution.
4. Ask students how the individuals profiled could reduce the pollution they cause.
5. Ask students to identify ways in which they pollute. Discuss measures that they can take to minimize their contribution to polluting the Ohio River.

Extension/ Evaluation

As a homework assignment, have students find pictures of polluters in magazines or newspapers and bring those pictures into class. Encourage students to identify subtle sources of pollution (such as nutrient contamination of streams caused by runoff from fertilized lawns). Discuss why the students feel that the pictures they have brought in indicate that pollution is occurring. Put together a pollution collage for the class. In addition, films or filmstrips on river pollution can be shown (consult Unit III, Section B, Resources).

Who Pollutes?

Martha Jones: Martha Jones is a mother and homemaker. Her activities include grocery shopping, preparing meals, doing laundry, and cleaning the house.

Joe Stone: Joe owns a large farm. He plows his land twice a year. Once a year he uses "Magic-Grow," a chemical fertilizer. He also uses "Bugs-Be-Gone," a popular insecticide, when necessary.

Sally Smith: Sally runs a small taxi company. Company taxis drive around town all day and night. Sally services all of the taxis herself by changing the oil, antifreeze, etc. She pours used oil and antifreeze into the closest storm sewer.

Carlos Rodriques: Carlos owns a steel plant along the Ohio River. Raw materials are shipped to his company and used to produce steel. Black smoke usually billows from the chimneys of the plant.

Robert Wang: Robert works as a machine operator in a coal-fired power plant. Water is used to cool the machinery. After it is used, the water is returned to the Ohio River.

Howard Shwartz: Howard is a bicycle courier. He delivers packages all over town.

B

Activity

Ground-Water Model

Objective

Students will demonstrate through building a model how aquifers are formed and ground water becomes polluted.

Setting

Classroom

Duration

One 1 1/2-hour period

Subject

Science

Skills

Observation, Analysis, Discussion, Experimenting, Media Construction, Comparing Similarities and Differences

Grade Level

3-6 (if teacher performs demonstration); 7-12 (if students build model)

Vocabulary

ground water   pollution   aquifer

Background Information

Refer to Unit III, Section B-5.

Materials

For each model

- Ground-Water Model handout.
- One 20 ounce clear plastic tumbler.
- 12 inches of clear plastic tubing.
- A small piece of nylon fabric to cover the end of the tubing.
- Masking tape.
- Small pebbles.
- Clean sand.
- Filter paper (e.g., a section of a coffee filter).
- Pump-type sprayer (e.g., from window cleaner).
- A disposable syringe.
- Red food coloring.
- A clear glass container.

Procedure

With younger students, the teacher should build the model as a demonstration. Older students can be divided into small groups to build the model, or can each build the model individually if there are enough materials. Have them use the Ground-Water Model handout for reference.

1. Define ground water and aquifers. Discuss with students the importance of ground water in the United States and the Ohio River Valley.
2. Secure nylon fabric over one end of the plastic tubing with masking tape or a rubber band.
3. Tape the tubing to the inside of the tumbler so that the nylon-covered end of the tubing *almost* touches the bottom of the tumbler.
4. Fill about one-third of the tumbler with pebbles.
5. Cut the filter paper into a circle with a diameter slightly larger than the diameter of the inside of the tumbler. Place the filter paper on top of the pebbles and tape it securely to the sides of the tumbler.
6. Fill the rest of the tumbler with sand.

Note: A shallow layer of potting soil can be added on top of the sand to represent the Earth's crust.

7. With the sprayer, apply water to the sand until it is saturated. The water will filter down into the pebbles.
8. Put the end of the syringe into the tubing and make sure the connection is tight.
9. Pull back the plunger of the syringe to create a vacuum. Water will be drawn from the pebbles/sand into the tubing and ultimately into the syringe. Discuss with students that this represents how ground water is pumped from aquifers.
10. Add a few drops of red food coloring to the sand. Explain to the students that the red food coloring represents a pollutant. Discuss what kinds of substances can pollute ground water.
11. Apply more water to the sand.

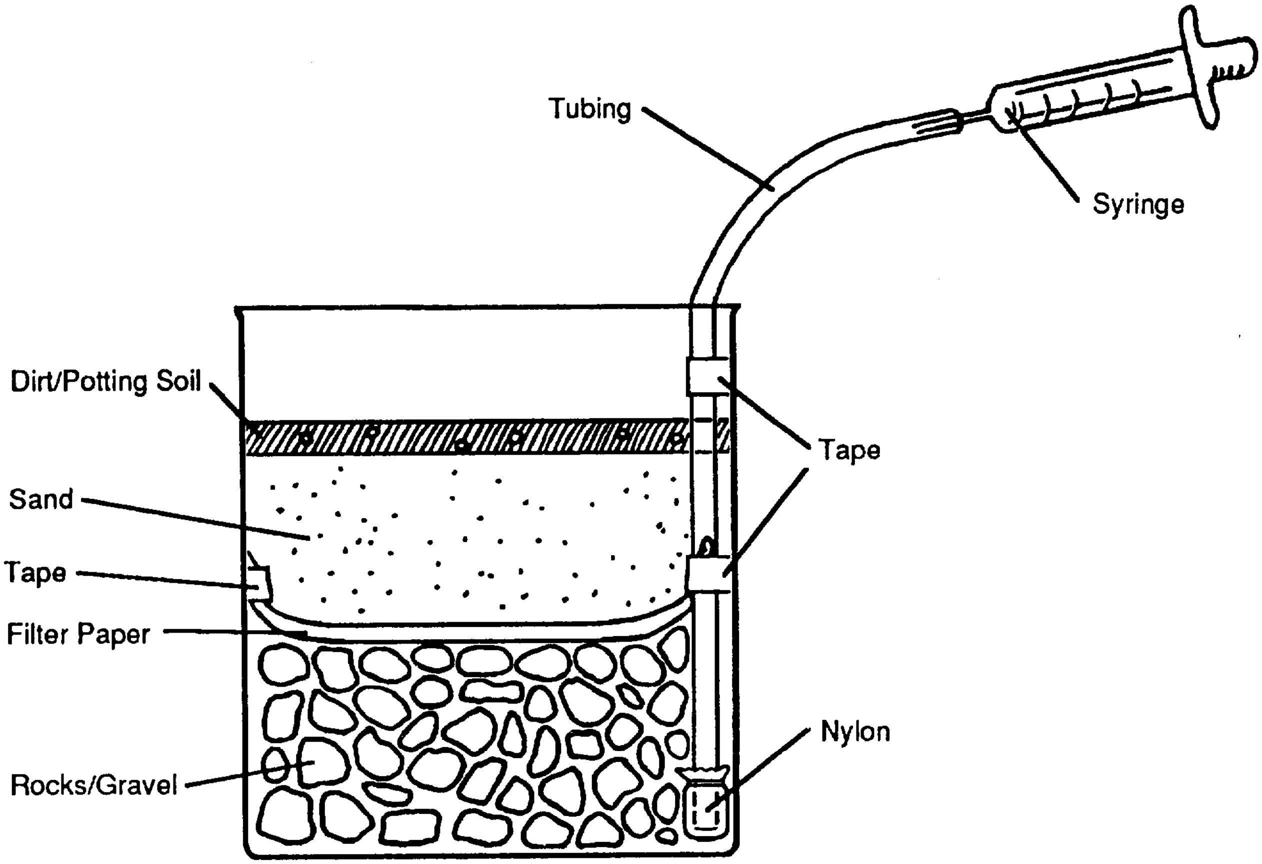
Procedure *(continued)*

12. Continue "pumping" water from the tumbler with the syringe. When the syringe fills with water, remove it from the tubing and pour the water into the clear glass container. Refasten the syringe to the tubing and continue "pumping" water. Ultimately, the water in the clear glass container will have a reddish hue. Discuss with students how the "pollutant" applied at surface level has "contaminated" the "ground water" in the experiment.

Extension/ Evaluation

Discuss with students how ground-water contamination occurs in real-life situations and how it can be prevented. In addition, a film or filmstrip can be shown on ground water (consult Unit III, Section B, Resources).

Ground-Water Model



B

Activity

Power Valley and the Impacts of Acid Rain

Objective

Students demonstrate the effects of acidity on plant life through a controlled experiment. They will also infer how power plants in the Ohio River Valley contribute to the acid precipitation problem.

Setting

Classroom

Duration

Two 1/2- to 1-hour periods and several 15-minute observation periods

Subject

Chemistry, Science, Social Studies

Skills

Analysis, Application, Comparing Similarities and Differences, Discussion, Experimenting, Inference, Recording Data

Grade Level

3-6, if teacher demonstrates experiment, and 7-12, if students conduct experiment themselves

Vocabulary

acid rain acid deposition coal-fired power plants
sulfur dioxide nitrogen oxide

Background Information

Refer to Unit III, Section B-6.

Materials

- pH testing kit (these are readily available in aquarium stores).
- Vases or cups.
- Plants that can be easily rooted, such as spider plants, golden pothos, and coleus.
- Vinegar.
- Baking soda.
- Copies of the handout, Ohio River Power Plants, Coal and Oil Fields, and Major Markets for Electricity.

Procedure

(With grade levels 3-6, the teacher should perform these steps. With grade levels 7-12, the students can perform these steps themselves.)

1. Test the pH of vinegar to demonstrate that it is an acidic substance.

Procedure *(continued)*

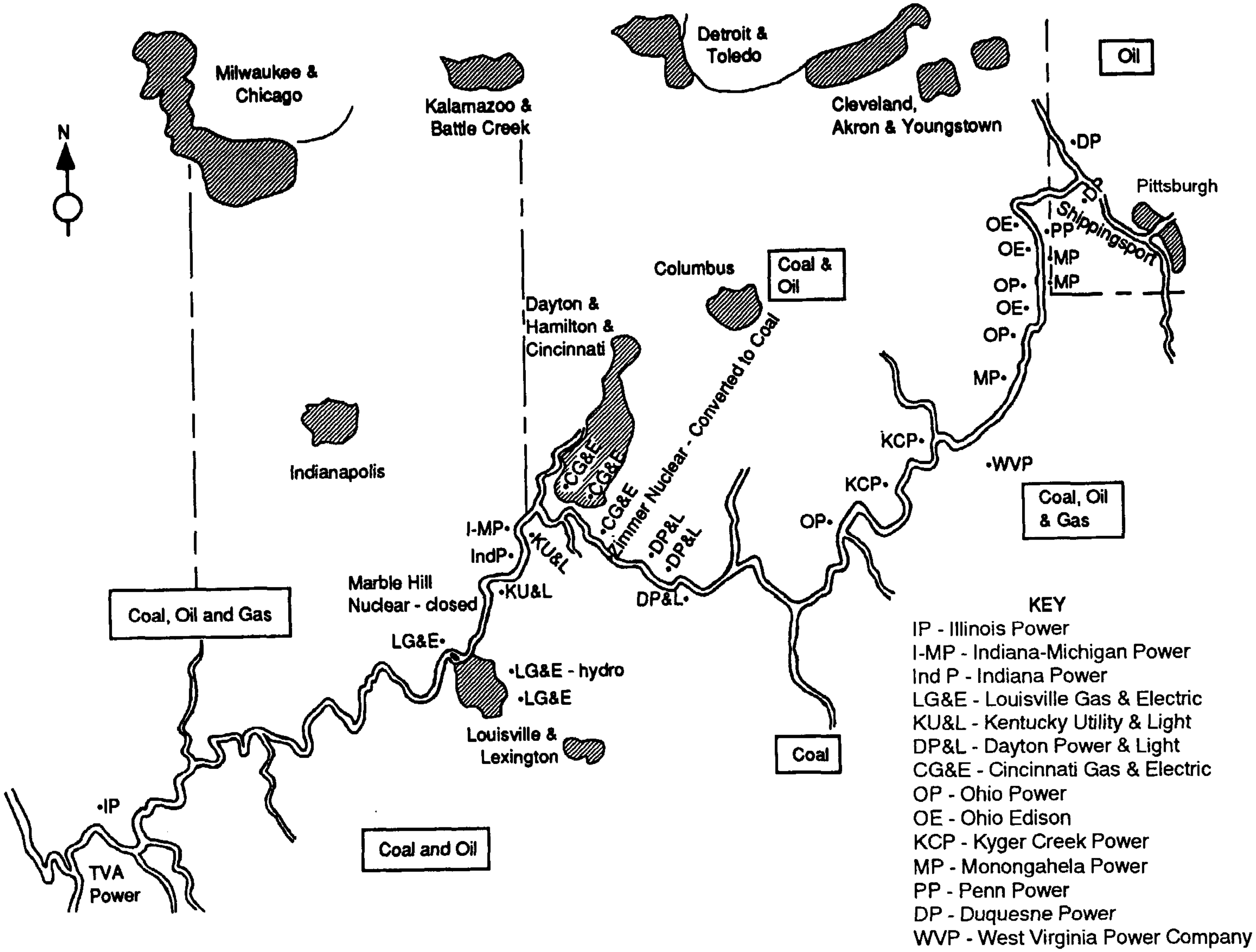
2. Mix vinegar with water and test the mixture. If the mixture has a pH of less than 4, add more water. If the mixture has a pH higher than 4, add more vinegar. Continue this process until a pH of 4 is reached.
3. Test tap water or distilled water. If the pH is lower than 7, add baking soda until a neutral pH is reached. If the pH is higher than 7, add vinegar until a neutral pH is reached.
4. Place several plants in vases or cups. Add the water with the pH of 4 to half of the vases or cups and add the neutral water to the other vases or cups.
5. Every few days, examine the root growth of the plants. Compare the root growth of plants in acidic water to those in neutral water. Record root growth results.
6. After a few weeks, have students make conclusions about the effect of acidic water on plant growth.

Discuss with students how acid rain is formed and help them to make the connection between what they have just observed and the potential impacts of acid deposition. Distribute copies of Ohio River Power Plants, Coal and Oil Fields, and Major Markets for Electricity to students and discuss with them the large number of power plants in the region. Explain the link between coal-fired power plants and acid rain. Ask students about the impact the power plants might have on the plant and animal life in the area.

Extension/ Evaluation

Have students collect rainwater samples in jars outside the classroom. Test the samples to determine if they are acidic. Have students collect water samples from lakes, ponds, swamps, streams, and rivers in their neighborhoods. Test these water samples to determine if they are acidic. Discuss the possible sources of the acidity and attempt to determine if acid deposition is a contributing factor. In addition, a film or filmstrip on the causes and/or effects of acid deposition can be shown (consult Unit III, Section B, Resources).

Ohio River Power Plants, Coal and Oil Fields, and Major Markets for Electricity



B

Activity Problems with Litter

Objective Students record data on pollution from litter and draw conclusions regarding the impacts of litter on the environment.

Setting Outdoors, along a riverbank

Duration 1/2 day trip, 1-2 hour wrapup

Subject Science, Social Studies

Skills Analysis, Discussion, Inference, Observation, Recording Data

Grade Level 4-12

Vocabulary litter degradable recycle

Background Information Refer to Unit III, Section B-7.

Materials

- Trash bags.
- Protective gloves (plastic or cloth).
- Notepads.
- Pens.

Procedure In preparation for the exercise, find a local area along a river or stream that needs to be cleaned up.

Note: Caution students to avoid picking up pieces of broken glass, sharp objects, or litter that may contain medical waste, such as syringes. Students should also wear protective gloves while working in the littered area.

1. Have students pick up litter within a specified area along the river or stream (a 50-yard stretch is recommended).
2. Students should work in pairs. Have one student collect litter while the other student records items that are collected.
3. Back in class, make a list on the board of all litter items collected.

Procedure

(continued)

Discuss with students the quantity of litter collected and the types of items found. Ask how the litter was deposited along the river (this discussion should cover littering by those who walk or drive along the river; littering by boaters; items being blown from landfills, garbage trucks, or barges into the river, etc.). Discuss with students why littering occurs and how it can be minimized. Ask if they litter, and if so, why.

Extension/ Evaluation

Ask students which litter items are degradable and discuss the long-term implications of degradability of litter. Discuss the negative impacts of littering (this should include aesthetic degradation; potential health problems, such as being cut on broken glass; wildlife entanglement in plastic rings or line; etc.). Ask students to devise schemes to minimize the impact of litter on wildlife, the environment, and human health.

Students may wish to "adopt a stream" by finding a river, stream, or creek in a public area near to school and taking responsibility for keeping it clean and healthy. For example, students might organize cleanups of the area, hold a "planting party" to plant trees or shrubs along the river or stream bank to control erosion, or patrol the waters for signs of pollution that should be reported to local authorities.

C Water Treatment: Yesterday and Today

1 The Overloaded Ohio River

Drinking water in the United States is among the safest in the world. One of the major sources of drinking water in the country is the Ohio River. The Ohio River is the principal source of water for many areas adjacent to its watershed. The water that flows in the Ohio River comes from precipitation that falls on the eight-state watershed and is carried through tributary streams into the river (see Unit I, Section A-1).

At one time, before the development of great cities and towns along its riverbanks, these waters were clean, pure, and safe to drink. However, with the increasing use of the river as a "dispose-all" for human and industrial wastes, it became apparent that untreated water was unsafe to drink. In fact, contamination can degrade the quality of water to the point where it cannot be used for any purpose.

Rivers can absorb some wastes. For example, some solid materials will naturally settle out in a river. Other wastes in the water will decompose over time. People once felt that the river's natural ability to absorb wastes would be enough to handle most pollutants, but today it is recognized that society has placed too great a burden upon the river's assimilating capacity.

2 Contaminants in Water Supplies: Microorganisms and Chemicals

Early in the nineteenth century, scientists first began to recognize that specific diseases could be transmitted by water through microorganisms such as **bacteria**. Since that discovery, treatment to eliminate disease-causing microorganisms has dramatically reduced the incidence of **waterborne diseases** such as typhoid, cholera, and hepatitis. For example, in 1900, 36 out of every 100,000 people died from typhoid fever; today there are almost no cases of waterborne typhoid fever in the United States.

Although water treatment processes have greatly improved the quality and safety of drinking water in the United States, many of the water sources in this country are still not adequately protected to prevent the transmission of some disease. Between 1971 and 1985, there were more than 500 outbreaks of waterborne disease reported in the United States, involving 110,000 illnesses related to contaminated drinking water. An outbreak is defined as two or more people contracting illness after using drinking water from the same source, a source that contains disease-causing microorganisms. Hikers and backpackers who drink from untreated and unfiltered rivers, lakes, and springs are particularly vulnerable to waterborne diseases because these supposedly "pristine" sources may contain disease-causing microorganisms.

The protozoan *Giardia lamblia* is the most commonly identified organism associated with waterborne disease in this country. This organism causes giardiasis, which usually involves diarrhea, nausea, and dehydration that can be severe and last for several months. Over 20,000 water-related cases of this disease have been reported in the last 20 years, with probably many more cases going unreported. Another protozoan disease, cryptosporidiosis, is caused by *Cryptosporidium*, a cyst-forming organism similiar to *Giardia*. Other common waterborne diseases include viral hepatitis, gastroenteritis, and legionellosis (Legionnaires' Disease).

Chemical contaminants, both natural and synthetic, also can be present in water supplies in amounts great enough to affect human health. Common sources of chemical contamination include pesticides, herbicides, and fertilizers used in agriculture; leaking underground petroleum storage tanks; industrial effluent pollution; seepage from septic tanks, sewage treatment plants, and landfills; and any other improper disposal of chemicals in or on the ground. In some cases, poor water quality can also promote corrosion of materials in the distribution system, possibly introducing lead and other metals into the drinking water. The water treatment process itself can also introduce some contaminants into water supplies such as trihalomethanes (see Unit III, Section C-4 below).

Prior to treatment, authorities will perform tests or use certain indicators to determine if water contains pollutants. Turbidity, or the amount of suspended particles in the water, is one indication that water may need treatment. (See Unit III, Section B-7 for more information on turbidity.) The presence of certain types of algae also indicates to water authorities that a river or waterway is polluted.

3 Milestones in Water Treatment

For thousands of years, people have treated water intended for drinking to remove particles of solid matter, reduce health risks, and improve aesthetic qualities such as appearance, odor, color, and taste. Today, the public is protected from the health risks of drinking water contaminants by regulations covering the quality, treatment, and sources of drinking water. The timeline below charts the progress that has been made from early water treatment methods to present day techniques and standards.

2000 B.C.: Sanskrit manuscript states: It is good to keep water in copper vessels, to expose it to sunlight, and filter it through charcoal.

Circa 400 B.C.: Hippocrates emphasizes the importance of water quality to health and recommends the boiling and straining of rainwater.

1832: The first municipal water filtration works opens in Paisley, Scotland.

1849: Dr. John Snow discovers that the victims of a cholera outbreak in London have all used water from the same contaminated well on Broad Street.

1877-1882: Louis Pasteur develops the theory that diseases are spread by germs.

1882: Filtration of London drinking water begins.

1890s: The Lawrence Experiment Station of the Massachusetts Board of Health discovers that slow sand filtration of water reduces the death rate from typhoid by 79 percent.

Late 1890s: The Louisville Water Company combines coagulation with rapid sand filtration. This treatment technique eliminates turbidity and removes 99 percent of bacteria from water.

1908: Chlorination is introduced at U.S. water treatment plants. This inexpensive treatment method produces water 10 times purer than filtered water.

1912: Congress passes the Public Health Service Act, which authorizes surveys and studies of water pollution, particularly as it affects human health.

1914: The first standards under the Public Health Service Act are promulgated. These introduce the concept of maximum permissible safe limits for drinking water contaminants. The standards, however, apply only to water supplies serving interstate means of transportation.

1948: Congress approves a Water Pollution Control Act. Its provisions, too, are restricted to water supplies serving interstate carriers.

1972: The Clean Water Act, a major amendment to the Federal Water Pollution Control Act, contains comprehensive provisions for restoring and maintaining all surface water bodies in the United States.

1974: The Safe Drinking Water Act is passed, greatly expanding the scope of federal responsibility for the safety of drinking water. Earlier acts had confined federal authority to water supplies serving interstate carriers. The 1974 Act extends U.S. standards to all community water systems with 15 or more outlets, 25 or more customers.

1977: The Safe Drinking Water Act is amended to extend authorization for technical assistance, information, training, and grants to the states.

1986: The Safe Drinking Water Act is further amended. Amendments set mandatory deadlines for the regulation of key contaminants; require monitoring of unregulated contaminants; establish benchmarks for treatment technologies; bolster enforcement powers; and provide major new authorities to promote protection of ground-water resources.

4 Methods for Treating Drinking Water and Wastewater

Drinking water treatment plants often combine several methods to produce safe, clean water in what is known as the multiple barrier approach. In addition to ensuring that ground-water and surface water sources of drinking water are protected from contamination by human and animal wastes, drinking water systems frequently employ two or more techniques to treat the water before distributing it to the community.

Disinfection, a chemical or physical process that kills disease-causing organisms, is the most common method of treating drinking water. For several decades, chlorine (as a solid, liquid, or gas) has been the disinfectant of choice in the United States because it is effective and inexpensive and can provide continuing disinfection in the distribution system. In some circumstances, however, chlorine can produce harmful by-products, called trihalomethanes. Because of the presence of trihalomethanes, some researchers suggest that long-term use of chlorinated drinking water may slightly increase the risk of certain types of cancer.

Small drinking water systems sometimes use ozone, an unstable form of oxygen, or ultraviolet radiation, as a primary disinfectant. Chlorine, or an appropriate substitute, must still be used as a secondary disinfectant, however, to prevent microorganisms from growing back when the water is distributed.

Filtration, which is often used in combination with disinfection, removes solid particles from water, usually by passing the water through sand or other porous material. Filtration helps to control the presence of bacteria and other disease-causing organisms, as well as the amount of suspended particles in the water. One of the most common filtration techniques, especially in rural areas, involves passing the water slowly through a sand filter, in a process called slow sand filtration. In urban areas, another filtration technique is often used in which water is passed rapidly through sand filters (rapid sand filtration). This technique requires less time than slow sand filtration, but the water must be pretreated. Pretreatment uses chemicals, such as alum, to form clumps, called floc, with water impurities so that they can easily be removed during the filtration process. Yet another filtration method commonly used involves passing water through filters made of diatomaceous earth, the remains of single-celled algae known as diatoms. Diatomaceous earth is used where water is relatively clear, and is common in swimming pool filters.

In addition to pretreatment, **sedimentation** is another step sometimes used in the drinking water treatment process. In sedimentation, heavy particles are allowed to settle out of water in holding ponds or large basins prior to filtration. Figure IIIC-1 shows a conventional treatment train that uses chemical pretreatment, sedimentation, filtration, and disinfection with chlorine.

A number of technologies also have been developed to treat or remove specific chemical contaminants. These contaminants may be either human-manufactured compounds containing carbon or inorganic contaminants. Inorganic contaminants are primarily naturally occurring elements in the ground such as arsenic, fluoride, sulfate, and radon. A common inorganic contaminant whose presence is concentrated in agricultural areas due to fertilizer application is nitrate. Other inorganic contaminants include lead, cadmium, copper, iron, and asbestos, which may result from corrosion in distribution pipes and plumbing systems.

Wastewater treatment plants, unlike drinking water plants, must convert an extremely concentrated brew of organic and inorganic waste material into water that can be safely discharged into public waterways. This waste originates in houses, business locations, and industrial plants everywhere with each flush of the toilet and many industrial processes. In addition, the combined sewers of most major cities add street wash from storms to this waste material.

All municipalities in the United States currently require both primary and secondary treatment for wastewater, in a process that typically removes up to 95 percent of the pollution from raw sewage. In addition, many systems use tertiary treatment, in which human-manufactured chemicals are removed. Before primary treatment occurs at the wastewater treatment plant, the sewage flow passes over a bar screen to remove large debris and through a grit chamber to remove sands that might damage plant equipment. Primary treatment begins with a large settling tank, where the wastewater is allowed to stand for 2 to 3 hours. Solid particles sink to the bottom of the tank; grease and oil float to the top. The goal of this stage of the process is to remove most of the solids that have been suspended and about one-third of the organic contamination.

In secondary treatment, water from primary treatment enters large tanks that are subjected to the mixing action of huge quantities of forced air. In these tanks, aerobic (oxygen-breathing) microorganisms degrade the incoming organic matter. After 6 to 8 hours of aeration, the water exits into a large clarifier tank where leftover solids and microbes sink to the tank bottom as sludge. This sludge is then withdrawn, with most going to be dried and eventually disposed of. But about one-quarter of the sludge returns to the aeration tank as "activated sludge" to mix again with fresh organic matter. The remaining water becomes crystal clear as the solids drop to the bottom.

The final step before the water is discharged into a lake, stream, or other water body is disinfection with chlorine or other chemicals to kill any lingering disease-causing organisms. Figure IIIC-2 shows a typical treatment train for a wastewater treatment plant.

5 Cincinnati: A Model of Water Treatment along the Ohio River

Over the years, technology has improved to the point where even water containing many contaminants can be treated with complete assurance of public health. The California potable water treatment facility in Cincinnati is one of the most advanced systems in the world.

Most of Cincinnati's drinking water comes from the Ohio River. When it is withdrawn, this water is first sent over a bar screen to remove large objects. It is then pretreated by being mixed with chemicals to produce clumping of solid particles (flocculation) to promote settling.

This water then moves upward through inclined tubes, where the solids aggregate and fall by gravity as sludge, which is then collected and removed.

The partially clarified water then flows to large holding basins. Here, the water remains until needed. When it is withdrawn for use, the water travels to large sedimentation basins where additional chemicals may be added to remove virtually all of the solids. The next step is rapid sand filtration.

Cincinnati has progressed beyond conventional treatment by adding an additional cleanup stage using a substance called granulated activated carbon (GAC). GAC is an additional step that will remove even tiny chemical pollutants that escape the sand filters. After this step, chlorine is added as a disinfectant. The treated water then goes to reservoirs and holding tanks throughout the city, awaiting final distribution to consumers' taps.

About 850,000 people throughout the city receive this water. Of the 135 million gallons of water produced each day, approximately 50 million gallons goes for household use. Another 62 million gallons goes to industry and commerical businesses, and the remaining water provides for fire protection, swimming pools, and other public and recreational uses.

Resources

Publications

Canby, T.Y. 1980. Our Most Precious Resource, Water. National Geographic. 158(2)152. August.

Decker, D.S. No Laughing Matter: Safeguarding Our Water Supply. The River Book, Cincinnati and the Ohio. 112 pp.

U.S. Environmental Protection Agency. 1986. Drinking Water: On Tap for the Future. EPA Journal, Vol. 12, No. 7. September.

U.S. Environmental Protection Agency. 1989. Protecting Our Drinking Water from Microbes. EPA 57019-89-008. August.

U.S. Environmental Protection Agency. 1990. Environmental Pollution Control Alternatives: Drinking Water Treatment for Small Communities. EPA/625/5-90/025.

U.S. Environmental Protection Agency. 1991. Series of Seven Algae Posters. Cincinnati, OH: Office of Research and Development. (Reprinted from U.S. Government Printing Office, 1978, 760-319.)

Resources *(continued)*

Audiovisual Programs

Clean Water. #IE-2514. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. Looks at the unsuspected environmental and health problems people unwittingly create at home, and offers suggestions on common household products (29 minutes). Rental: $75.

Element 3. International Film Bureau, 332 South Michigan Ave, Chicago, IL 60604-4382, 312-427-4545. A look at the contrast between the lyrical beauty of pure water and the aridity of its absence. Focuses on cooperation, which is essential for the distribution of water.

Fit to Drink. #IE-1674. Films for the Humanities and Sciences, 743 Alexander Road, P.O. Box 2053, Princeton, NJ 08540, 1-800-257-5126. Traces the water cycle beginning with the collection of rainwater in rivers and lakes, through a water treatment plant, through human usage, and back to the atmosphere. Examines current techniques for the treatment of water (20 minutes). Rental: $75.

Pollution, the First. 1972. Stuart Finley, Inc. 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. Water quality management ideas for cities and towns (26 minutes). Junior to senior high school levels. Rental: $35.

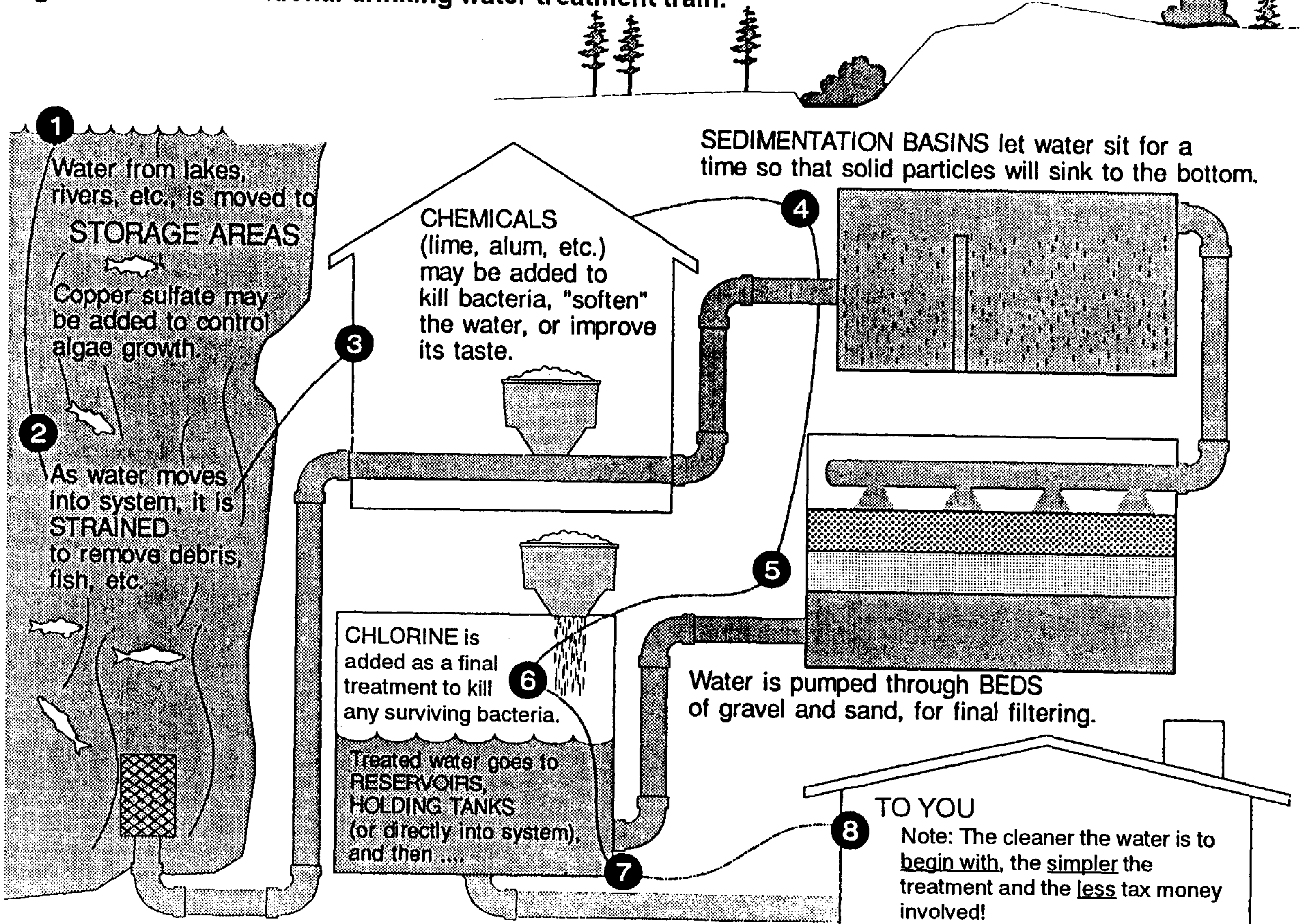
Problems of Conservation: Water. Encyclopaedia Britannica Educational Corporation, 310 S. Michigan Ave., Chicago, IL 60604, 1-800-554-9862. Provides examples of water pollution problems and shows how dirty water can be treated and returned to its pure state.

Sewers. 1978. Stuart Finley, Inc. 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. How a big city sewer system works and how to manage it (20 minutes).

The Valley. 1974. Stuart Finley, Inc. 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. The Ohio River Valley water quality management programs (28 minutes). Junior to senior high school levels. Rental: $35.

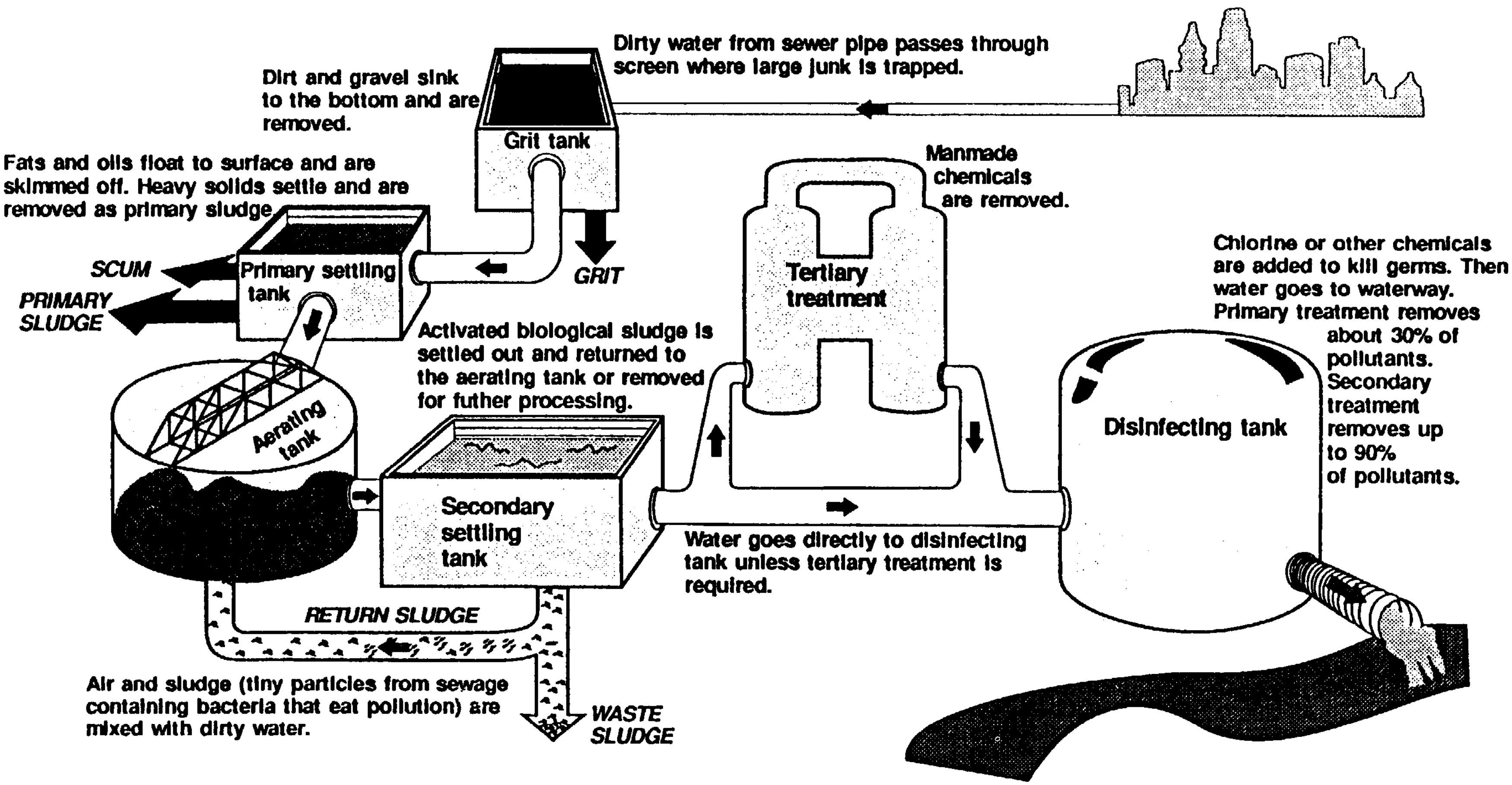
Water for the City. #70194. Phoenix Films, Inc. (BFA Educational Media), 468 Park Ave. South, New York, NY 10016, 1-800-221-1274. Where cities get their water and how people get it to their homes (11 minutes). Primary and intermediate grade levels.

Figure IIIC-1. Conventional drinking water treatment train.



Note: This represents a basic water treatment plant setup. Individual steps may vary depending on system budget and size.

Figure IIIC-2. Typical wastewater treatment train.



C

Activity

Looking at Algae

Objective

Students will analyze water samples for algae growth and make a determination about the quality of the water sample.

Setting

Classroom

Duration

One 40- to 50-minute period

Subject

Art, Biology, Health, Science

Skills

Analysis, Application, Discussion, Observation, Recording Data, Comparing Similarities and Differences, Inference, Identification, Drawing, Small Group Work

Grade Level

3-12

Vocabulary

algae

Background Information

Refer to Unit III, Section C-2.

Materials

- Microscopes.
- Slides with water collected from different sources.
- Types of Algae handout.
- Some field guides that include pictures and descriptions of algal forms. A good source is *Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes* by George Reid (New York, NY: Golden Press, 1967). Another good reference is the Series of Seven Algae Posters (Government Printing Office, 1978. 760-319. Reprinted by EPA Office of Research and Development in 1991). These posters can be obtained free of charge from EPA by calling 513-569-7771.

Procedure

1. Collect water samples the day before the lab from several different sources and label the samples with the location. Try to collect from areas with algal growth ranging from water that is almost clear to water that is covered with a dense algal mass. (See Appendix B, "Field Ethics: Determining What, Where, and Whether or Not!")
2. Add a drop of dishwashing soap to each sample then apply samples to slides.

Procedure

(continued)

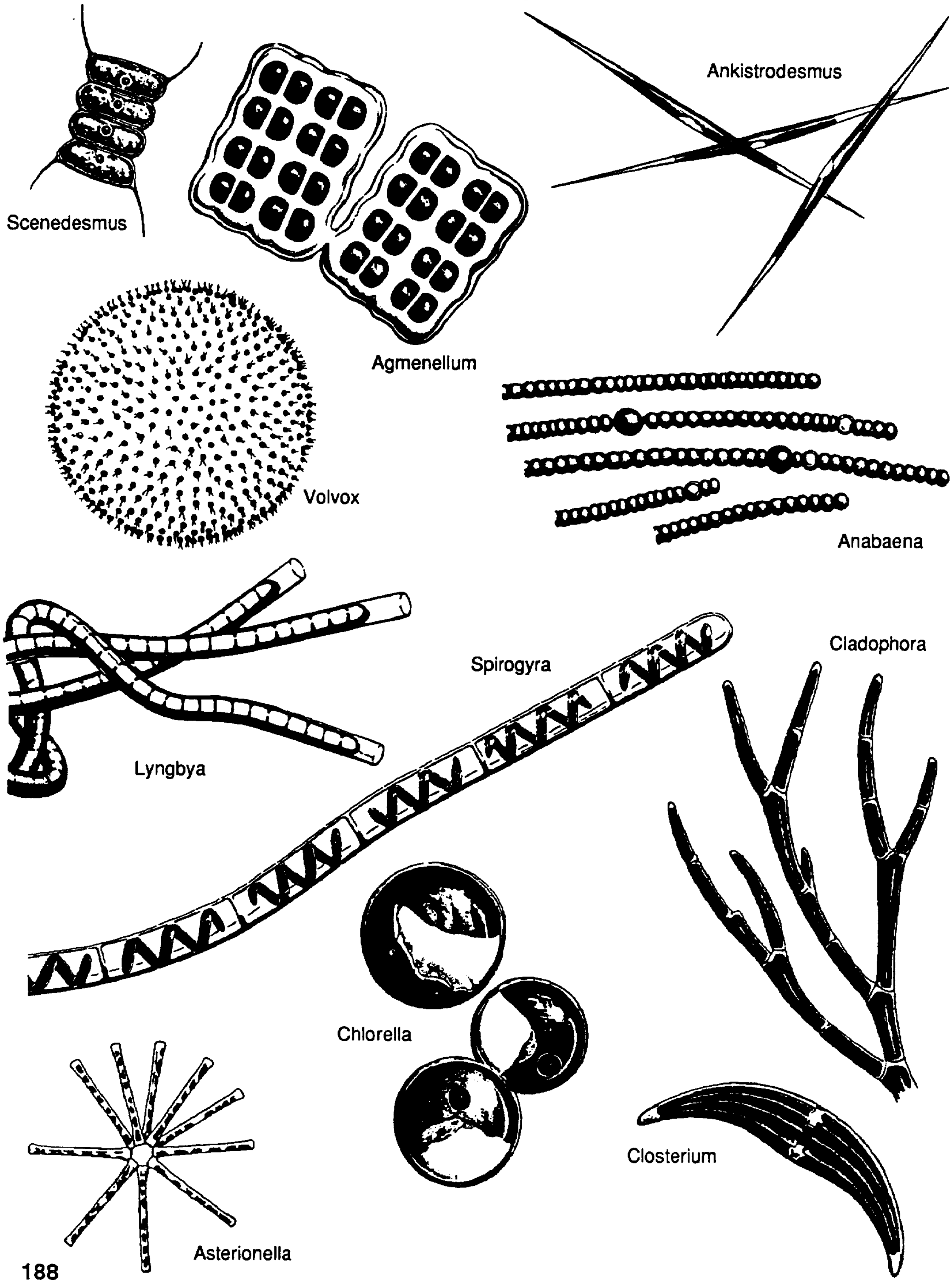
3. Divide students into as many small groups as there are microscopes. If you have enough microscopes, you may want to let each student use his or her own.
4. Put one slide from each sample at each microscope station.
5. Have students take turns examining the different samples and drawing sketches of what they see on each slide. Ask them to compare the slides for numbers and types of algae.
6. Give students time to refer to the Types of Algae handout or to field guides and other resources to name some of the algae that they see.

After students have had a chance to draw and research their algal forms, explain to students that the presence of certain types of algae indicate that a river or waterway is polluted and needs to be treated before it can be used by humans. Based on this information, ask students if they can guess which of the samples that they studied came from water sources that were potentially polluted.

Extension/ Evaluation

Arrange a field trip so that students can visit some or all of the sites where the samples were collected. Ask them to look for reasons why some of the waters are polluted and others are cleaner or clearer. Possible reasons might include visible effluent outfalls, proximity to areas with lots of litter, lack of water movement, or dead or decaying organic matter.

Types of Algae



C

Activity

How Clean Are Your Hands?

Objective

Students will demonstrate the value of proper hygiene by observing how water alone and water together with soap can remove potentially harmful bacteria from our bodies.

Setting

Classroom

Duration

1 hour initially, then 30 minutes each day for 4 additional days

Subject

Biology, Health

Skills

Experimenting, Observation, Comparing Similarities and Differences, Synthesis, Graphing, Recording Data, Small Group Work, Discussion

Grade Level

9-12

Vocabulary

bacteria   waterborne disease

Background Information

Refer to Unit III, Section C-2.

Materials

- Three nutrient agar petri plates per student.
- One microscope per student or small group of students.
- Running water.
- Soap.
- Incubator or a warm area.
- Wax pencil.

Procedure

Discuss the concepts of bacteria and waterborne disease with students. Explain that some organisms can cause disease if they enter the mouth or get into a cut on our bodies. These organisms can be found everywhere, including in water. Explain to the students that they will conduct an experiment to learn about environments that promote the growth of bacteria.

Have each student follow these steps:

1. Put your name on the bottom of three petri plates containing nutrient agar (culture media) and number them 1 through 3.
2. Remove the lid of plate #1 and touch the agar with your finger.

Procedure *(continued)*

3. Run water over your hands, dry, and touch plate #2.
4. Wash your hands with soap and water, dry, and touch plate #3.
5. Turn all plates upside down and store in a warm area (such as near a heater) or in an incubator (30 degrees Celsius).
6. Check the plates daily for a week to see the amount and diversity of growth in plates #1, #2, and #3. Count the colonies (populations of cells arising from single cells) under a microscope and graph the number of colonies as a function of days for each plate. In addition, or as an alternative, you may wish to have students draw what they see each day in every plate.
7. Discuss with students the results of their experiment:
   - At the end of the week, which plate contained the greatest number of colonies? Can you guess why?
   - Which plate contained the fewest colonies? Why?
   - How fast did colonies grow from day to day on the three plates?
   - What conclusions can you draw from your experiment that might be applicable in people's daily lives?

Extension/ Evaluation

Collect data (graphs) from all the students and post them on the bulletin board. Have students compare their data with others. Were all of the results identical? Ask them to account for any differences. Repeat the experiment with students using different brands of soap. Compare results and discuss any conclusions.

C

Activity

Function of Filters

Objective
Students will observe how an actual filter functions and draw conclusions relating filtration to water purity.

Setting
Classroom.

Duration
15 minutes each day for 4 days

Subject
Science

Skills
Observation, Comparing Similarities and Differences, Experimenting, Inference, Synthesis, Prediction, Discussion

Grade Level
K-6

Vocabulary
filter sewage wastewater treatment plants

Background Information
Refer to Unit III, Sections C-3 and C-4.

Materials

- Two goldfish.
- Two fishbowls filled with water. These should sit out overnight before the experiment so that chlorine in the water will evaporate.
- A water filter.
- Notebooks and pens or pencils.

Procedure

1. Introduce students to the concept of filters and explain that they are going to participate in a demonstration to see how filters function.
2. Put a water filter unit in one of the two fishbowls.
3. Add one fish to each bowl.
4. At the same time each day for 3 consecutive days, check on the two bowls with the students. Ask them to compare the two bowls and describe the differences. Have the students record their observations each day in a notebook.
5. At the end of the third observation period, ask students the following questions:

Procedure *(continued)*

- What might happen if we continued this experiment for another week?
- Why are filters in aquariums necessary for the health of the fish and other living things in them?
- What other types of filters do you know about and what function do they serve? (Students might mention coffee filters, pool filters, or oil filters.)

Conclude with a discussion of the use of filters in water treatment plants to purify water containing sewage and other pollutants.

Extension/ Evaluation

Ask students why fish and other wildlife in rivers, streams, lakes, and other natural water bodies do not need filters to stay healthy. Help students to understand that there are natural sources of filtration and purification that keep water clean including settling of heavy particles, movement of water through pebbles or sand, and the metabolism of plants and other microorganisms (refer to Unit II, Section B for a discussion of the properties of water and to Unit III, Section B for more information on water pollution). Explain to students, however, that often even in the wild, pollution becomes so great in a single area, that these natural treatment methods are not enough to keep water pure.

Take a field trip to a local aquarium to learn about the use of filters on a larger scale. Ask a member of the aquarium staff to explain to your class the importance of filters in their facility and, if possible, to show the students how these filters work.

C

Activity

How Water Is Cleaned

Objective Students will perform an experiment that demonstrates the procedures used by municipal water plants in purifying water for drinking.

Setting Classroom

Duration One 40-minute period

Subject Chemistry, Health, Science, Social Studies

Skills Analysis, Application, Discussion, Experimenting, Evaluation, Observation, Synthesis, Comparing Similarities and Differences

Grade Level 7-12

Vocabulary drinking water treatment plants disinfection filtration aeration sedimentation floc

Background Information Refer to Unit III, Section C-4.

Materials

- How a Water Treatment System Works handout.
- A collection bucket containing 5 liters of "swamp water" (or add 2 1/2 cups of dirt or mud to 5 liters of water).
- One 2-liter plastic soft drink bottle with its cap (or a cork that fits tightly into the neck of the bottle).
- Two 2-liter plastic soft drink bottles—one bottle with the top removed and one bottle with the bottom removed.
- One 1.5-liter (or larger) beaker or another soft drink bottle bottom.
- Two tablespoons of alum (potassium aluminum sulfate—available at a pharmacy).
- Fine sand (about 800 milliliters in volume).
- Coarse sand (about 400 milliliters in volume).
- Small pebbles (about 400 milliliters in volume).
- Large beaker or jar (500 milliliters or larger).
- Small piece of flexible nylon screen (approximately 5 centimeters x 5 centimeters).

Materials

(continued)

- A tablespoon.
- A rubberband.
- A clock with a second hand or stopwatch.

Procedure

1. Pour about 1.5 liters of "swamp water" into a 2-liter bottle. Have the students describe the appearance and smell of the water. Tell students that each step you are about to perform corresponds to a stage of conventional water treatment.
2. Aeration. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cutoff bottles, then pouring the water back and forth between the cutoff bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off. Explain that this process allows gases trapped in the water to escape and adds oxygen to the water.
3. Coagulation. Add approximately 2 tablespoons of alum crystals to the water. Slowly stir the mixture for 5 minutes. Explain that particles suspended in the water will clump together with the alum to produce floc.
4. Sedimentation. Allow the water to stand undisturbed in the bottle. Have students observe the water at 5-minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance. The floc should settle to the bottom.
5. Filtration. While the floc is settling, construct a filter from the bottle with its bottom cut off:
   - Attach the nylon screen to the outside neck of the bottle with a rubberband. Turn the bottle upside down and pour a layer of pebbles into the bottle—the screen will prevent the pebbles from falling out of the neck of the bottle.
   - Pour the course sand on top of the pebbles.
   - Pour the fine sand on top of the course sand.
   - Clean the filter by slowly and carefully pouring through 5 liters (or more) of the clean tap water. Try not to disturb the top layer of sand as you pour the water.

Procedure ***(continued)***

After a large amount of the floc has settled, carefully—and without disturbing the sediment—pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water into the collection bucket. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

6. Disinfection. Inform students that a water treatment plant would, as a final step, disinfect the water (e.g., would add a disinfectant such as chlorine) to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.

7. Ask students the following questions to trigger discussion of what they observed:

   - What was the appearance of the original swamp water?
   - Did the aeration process change the appearance or smell of the water? (If the original sample was smelly, the water should have less odor. Pouring the water back and forth allowed some of the foul-smelling gases to escape to the air of the room.)
   - How did sedimentation change the water's appearance? Did the appearance of the water vary at each 5-minute interval? (The rate of sedimentation depends on the water being used and the size of alum crystals added. Large particles will settle almost as soon as stirring stops. Even if the water contains very fine clay particles, visible clumps of floc should form and begin to settle out by the end of the 20-minute observation period.)
   - How does the treated water (following filtration) differ from the untreated swamp water? (The treated water should look much clearer and have very little odor.)

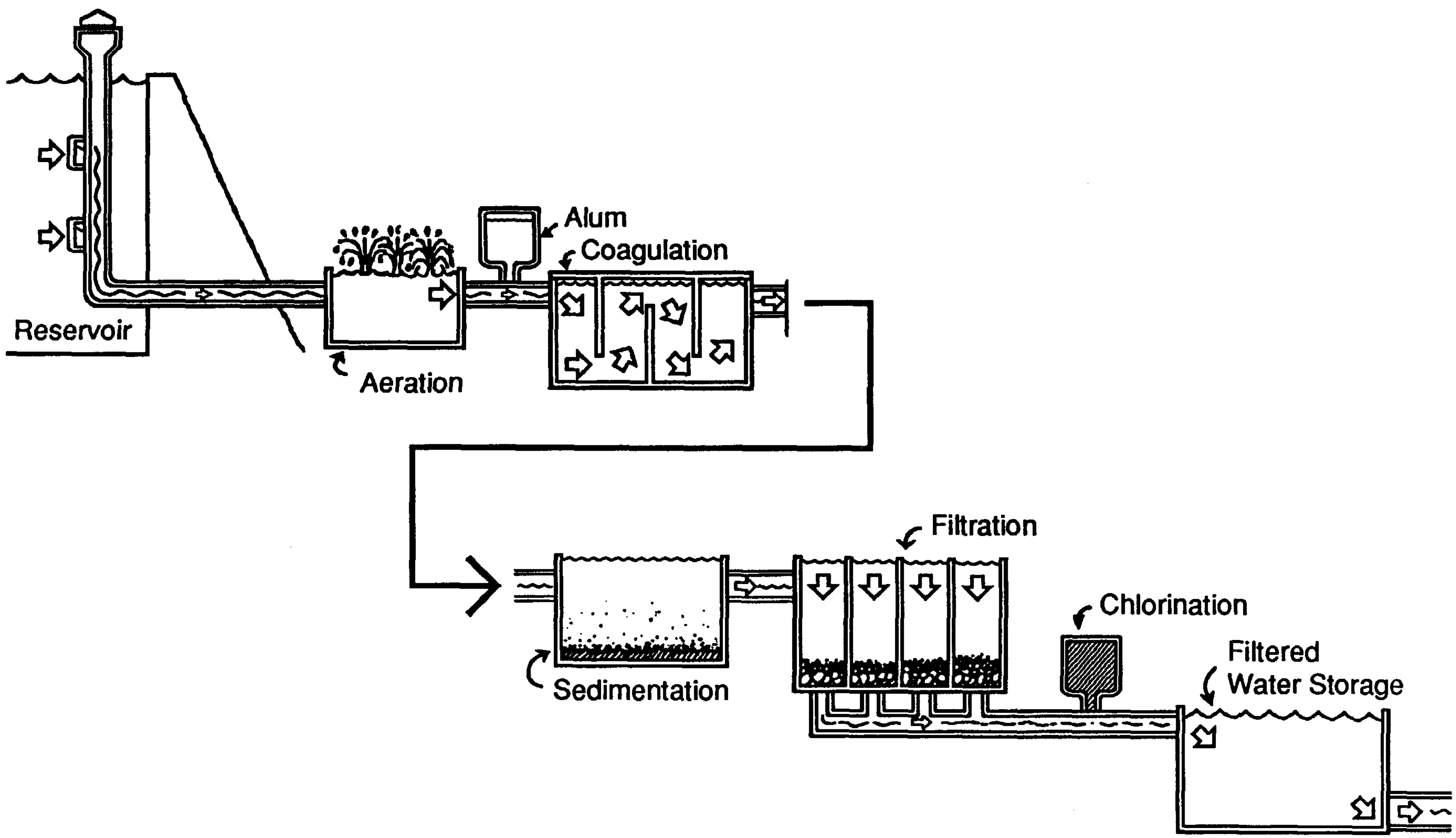
After the experiment, distribute copies of the How a Water Treatment System Works handout. Compare the steps you have just performed with those in a water treatment plant.

Extension/ Evaluation

Arrange for a tour of a local drinking water treatment plant where students will be able to observe firsthand a number of the processes shown in the demonstration. Have each student come up with at least one good question to ask plant personnel about the treatment process, based on what they learned during the demonstration. Review these questions before the field trip and, if possible, share some of the best ones with plant personnel in advance so they can better respond to your students' interests. After the field trip, discuss with students how the water treatment plant processes differed from those in the demonstration and how they were similar.

Adapted with permission from: Gartrell, J.B. Jr., J. Crowder, and J. C. Callister; Earth: The Water Planet (Washington, DC: The National Science Teachers Association, 1989).

How a Water Treatment System Works



D Economics and the Environment: Ensuring a Healthy Tradeoff

1 Meeting Human Needs

The factories, farms, businesses, and residential developments that have sprung up along the banks of the Ohio River provide people with a variety of valuable services, including shelter, food, employment, and other necessities. In addition, the river is a prime highway for transportation and commerce and an important source of energy in the form of electricity. The construction of marinas, dams, and flood control measures also allows the river to be used recreationally for such activities as boating, fishing, and river-oriented festivals.

Thousands of people are employed in careers that are directly and indirectly tied to the river. Locks and dams, which facilitate river transportation (see Unit III, Section B-3), employ people who serve as lock masters, operators, and maintenance personnel. In addition, the Corps of Engineers operate and repair the locks, as well as building landing ramps and adjacent parks for boaters, making maps, dredging the channels, issuing permits for new river facilities, and clearing wrecks and other hazards from the river. The U.S. Coast Guard also aids navigation on the river by inspecting boats and boating equipment for safety, issuing licenses to commercial navigators, maintaining lights and buoys, and investigating boating accidents.

River terminals along the Ohio River employ hundreds of workers to load and unload goods such as coal, gasoline, steel, and salt from shipping barges. Towing and tugboat industries help the barges navigate in and out of these terminals. There are also many jobs for engineers, navigators, and maintenance personnel onboard the barges and other commercial and recreational boats.

Other important river businesses include water treatment plants that purify and provide water to many cities along the banks of the Ohio River, and power plants that supply electricity to many of these same cities. The fire department patrols the river for fires and has a fire boat to meet emergencies. Other organizations provide services to the river's many recreational users. These businesses include floating gas stations, repair facilities, marinas, boat and equipment sales, and floating restaurants. There are even educational barges, such as the Marilyn K. McFarland tugboat that provides vocational training to young men and women in the marine industry, and the floating exhibition, *Always a River: The Ohio River and the American Experience,* which explores the cultural and natural history of the Ohio River.

2 The Costs of Economic Growth

Riverfront development, whether commercial or private, must take into account the costs of encroaching on the river system even as it accommodates people's expectations of a better lifestyle. Development can deplete scarce resources and promote overcrowding. Pollution from contaminated sediments, runoff, and factory emissions affects water quality and, consequently, human health. River traffic requires locks and dams and occasional dredging to maintain navigability, which may have consequences for the aquatic life of the river. Floodplain development requires special flood control construction and channel protection activities that also may have negative effects on the river's ecosystem. In addtion to these environmental costs, unchecked economic growth can even lead to increased monetary costs due to expensive cleanup efforts.

3 Unlimited Use Versus Conservation

Many of the alternative uses of the rivers and wetlands of the Ohio River Basin are in competition with one another. Industrial, commercial, recreational, and residential demands cannot all be met with the same scarce resources, and all of these demands must be weighed against preserving the quality of the environment. Achieving a balance between these uses and conservation is important because development affects not only the natural environment but human welfare as well.

The public's access to clean water is a good illustration of how degraded environmental quality affects individuals. The cost of drinking water treatment depends on the amount of pollution present in the water being treated. Consumers must pay to remove contaminants and purify water not only for human consumption but also for industrial, commercial, and recreational use. The dirtier the water, the more the consumer must pay. So even from a purely economic standpoint, unlimited industrial and commercial use of a resource such as the Ohio River is not always the most profitable.

The decision of how (or if) to use a resource requires a **tradeoff** of goals. If a resource is used for one thing, it may be unavailable for another use. The **opportunity cost** is that next best use or choice that cannot be accomodated. For example, if a riverfront area is developed as a shopping district, it cannot at the same time be used as a recreational beach or a waterfront park. The loss of the opportunity to use the area as a beach or park is the opportunity cost of increased shopping and employment. Because people always give up some uses when they elect others, an important component of any usage decision is that it be carried out with the least waste and the least impact on the environment. This type of careful planning will reduce both economic and environmental costs. If any use involves a tremendously high economic or environmental cost, perhaps it is a signal that alternative uses or goals should be sought.

As economic growth continues, people must become more mindful of their ability to cause what may be irreparable harm to the environment. Wise decisions concerning the use of scarce resources should include consideration of the tradeoffs between the short-term benefits of economic progress and the long-term costs of environmental decline. Some of these long-term costs are aesthetic and moral as well as economic. For example, the value of an endangered species may not be measurable in economic terms. Once an animal becomes extinct, however, it can never be brought back to life. Other environmental problems, such as depletion of the ozone layer, may be irreversible.

Education plays an important role in making people aware of the limits of natural resources and the costs associated with their indiscriminate use. To make sound choices requires a knowledge and concern for costs as well as benefits. If people recognize the scarcity of resources such as clean water, a healthy river, and productive wetlands, they will be more likely to make the best use of them.

4 The Role of the Government in Protecting the Nation's Waters

Water pollution has long been considered an environmental problem of national significance. The U.S. Environmental Protection Agency (EPA) in partnership with state and local agencies has set a goal of improving and protecting water quality. These agencies are committed to maintaining high drinking water quality, preventing further degradation of critical aquatic habitats, and reducing pollution in free-flowing surface water.

The U.S. Congress has given EPA, the states, and Indian tribal governments broad authority to deal with water pollution problems. The principal mechanism Congress has used to grant such authority is the Clean Water Act (CWA), passed in 1972 to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." EPA has developed regulations and programs under the CWA to reduce the quantity and toxicity of pollutants entering surface waters within the United States. In 1987, Congress strengthened the CWA by enacting amendments to this legislation in the Water Quality Act. These amendments ensured that support for municipal sewage treatment plants would be maintained, initiated a new state-federal program to control nonpoint source pollution, and set up a more stringent time table for the implementation of tighter controls on toxic pollutants.

Another law enacted by Congress to address problems of freshwater pollution is the Safe Drinking Water Act (SDWA) of 1974. The SDWA, which was amended in 1986, requires EPA to establish drinking water standards and to develop standards to protect underground sources of drinking water from contamination. Other environmental laws, such as the Resource Conservation and Recovery Act (RCRA), and the Toxic Substances Control Act (TSCA) help to improve water quality by controlling the quantity and toxicity of chemicals being released to the environment. The U.S. Army Corps of Engineers is also required to regulate certain activities in all waterways, such as construction, excavation, and discharge or deposition of materials, under the River and Harbor Act of 1989 and Section 404 of the CWA.

The CWA and SDWA, as well as other environmental laws, have been called upon extensively to reduce pollution in the Ohio River and its tributaries. Federal legislation of this kind together with state standards have paved the way for the development of ordinances and regulations to safeguard the water quality of the Ohio River Valley.

5 Leadership in Environmental Research

Developing laws that regulate pollution and protect the quality of waterways such as the Ohio River is a complex process. Extensive research must be conducted to generate the scientific and technological tools necessary to understand the causes, extent, and consequences of pollution and to develop strategies for its prevention and abatement.

These research efforts provide the foundation of knowledge for formulating environmental policy and regulations.

With the establishment of the Andrew W. Breidenbach Environmental Research Center (AWBERC), EPA brought together internationally renowned scientists and engineers to form EPA's largest water research and development program. Coordinating the efforts of these experts, EPA has made great progress in cleaning up the nation's waterways. EPA's research concentrates not only on obvious pathways of water quality degradation such as industrial discharges, municipal sewage treatment wastes, and chemical spills, but has expanded in focus to include more subtle routes of pollutant transport such as stormwater runoff, air contaminant deposition on surface waters, and the discharge of polluted ground water into rivers and streams. Additionally, AWBERC performs significant research on evaluating ecological risks to provide criteria for prioritizing pollution regulation strategies.

AWBERC uses state-of-the-art equipment and methods to perform research. Short-term research projects have been very successful in investigating and solving current environmental problems, while long-term research has proven valuable in identifying and understanding the cumulative effects of contaminants over time. Scientists and engineers at AWBERC currently are participating in designing the Environmental Monitoring and Assessment Program (EMAP). EMAP, when fully implemented, will provide periodic reports on the condition of national ecological resources, such as the Ohio River, based on the results of monitoring numerous indicators of environmental exposure.

Improving water pollutant monitoring methods and technology is an important EPA goal. Toward this effort, AWBERC's "biomarkers" research investigates methods to measure contamination levels in tissues of living organisms. This information will contribute to the development of standards for evaluating the ecological condition of a particular medium (air, water, land). For example, scientists are perfecting methods to measure the levels of various blood components (much like those checked by a physician during routine physical exams) of fish captured in area streams and rivers. These results are then correlated with the measured ecological condition of a particular water body to establish trends. Based on these trends, scientists will quickly be able to determine the condition of a stream or river using the blood analyses of the fish living there.

Other areas of EPA research include the effects of specific chemicals and mixtures on human health and the environment. AWBERC personnel have been called upon to investigate waterborne disease outbreaks worldwide. At an EPA laboratory next to the Cincinnati municipal wastewater treatment plant, technologies for treating wastewater and sludge are being developed and tested. AWBERC also runs several drinking water treatment plants to determine how effective certain treatment processes, such as filtration and aeration, are at removing contaminants from potential drinking water. Additionally, EPA scientists survey the quality of community drinking water supplies across the country.

The environment cannot be protected simply by responding to instances of contamination. Recycling, reuse, and reduction practices must be stressed to effectively prevent pollution. For this reason, EPA places a great deal of emphasis on environmental education. Through AWBERC, EPA's Office of the Senior Official for Research and Development (OSORD) organizes seminars on environmental topics, prepares environmental education materials, and hosts visits from many schools and community groups. On the international front, AWBERC hosts over 100 visits each year from representatives of foreign countries and conducts research projects in cooperation with many foreign governments. From the transfer of technology and information to the promotion and support of educational programs such as "Always a River," EPA's Andrew W. Breidenbach Environmental Research Center encourages investigation and understanding to assure the preservation of the nation's natural resources.

Resources

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Good Riddance. 1960. Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. Pollution control efforts along the Ohio River Valley (25 minutes). Junior to senior high school level.

Ohio River: Industry and Transportation. #70924. Phoenix Films (BFA Educational Media), 468 Park Ave. South, New York, NY 10016, 1-800-221-1274. The Ohio River travels from Pittsburgh, Pennsylvania, to Cairo, Illinois. Shows how industry uses locks and dams for transportation, but also presents the pollution problems that have resulted (16 minutes). Intermediate and junior high school levels.

The Valley. 1974. Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, VA 22041, 703-820-7700. The Ohio River Valley water quality management programs (28 minutes). Junior to senior high school levels. Rental: $35.

D

Activity

Planning for the Future

Objective

Students will learn to balance a variety of economic needs with environmental concerns by creating a land use plan for a model community.

Setting

Classroom

Duration

One to three 40-minute class periods

Subject

Social Studies, Art

Skills

Media Construction, Decision-Making, Application, Synthesis, Communication, Public Speaking, Mapping, Discussion, Small Group Work

Grade Level

K-6

Vocabulary

use conservation

Background Information

Refer to Unit III, Sections D-1 through D-3.

Materials

For each student

- Community Landmarks handout.
- Habitat handout.
- Scissors.
- Construction paper.
- Glue.

Procedure

1. Explain to students that they are going to have a chance to plan their own community. Discuss the necessity of balancing different needs when deciding what to include in their plans. Introduce the terms "conservation" and "use" and explain the importance of each.
2. Pass out materials to each student, including the two handouts. Explain to them that they will begin by cutting out the habitat on the Habitat handout and glueing it onto a large piece of construction paper. This is the land on which they will develop their community.
3. Next, have students cut out the landmarks on the second handout. Define any of the landmarks with which the students are unfamiliar.

Procedure *(continued)*

4. Tell students that they must decide which landmarks to include in their community and glue them down on the habitat where they belong. (For example, if students choose to use the barge facility or the public marina, it should be glued next to the river.) Explain to students that they do not need to use all of the landmarks and, if they choose, they can set aside some of the land for conservation.

Note: Alternatively to Steps 3 and 4, you may wish to write a list of possible landmarks on the board, and allow students to design their own out of construction paper, label them, and attach them to their habitats.

5. When students have completed their community plans, allow them to explain why they made the decisions they did. This can be done in individual conversations with the student or in small groups. Older children may wish to present their land use plans to the whole class. In your discussions, ask questions such as the following:
   - What uses will your community make of the river? How will these uses affect the river?
   - What will happen to the marsh under your plan?
   - Where will the people live?
   - Where will they work?
   - Have you included any conservation land in your plan? Why or why not?
   - What are some of the most important features of your community?
   - What will happen if more people move to the community?

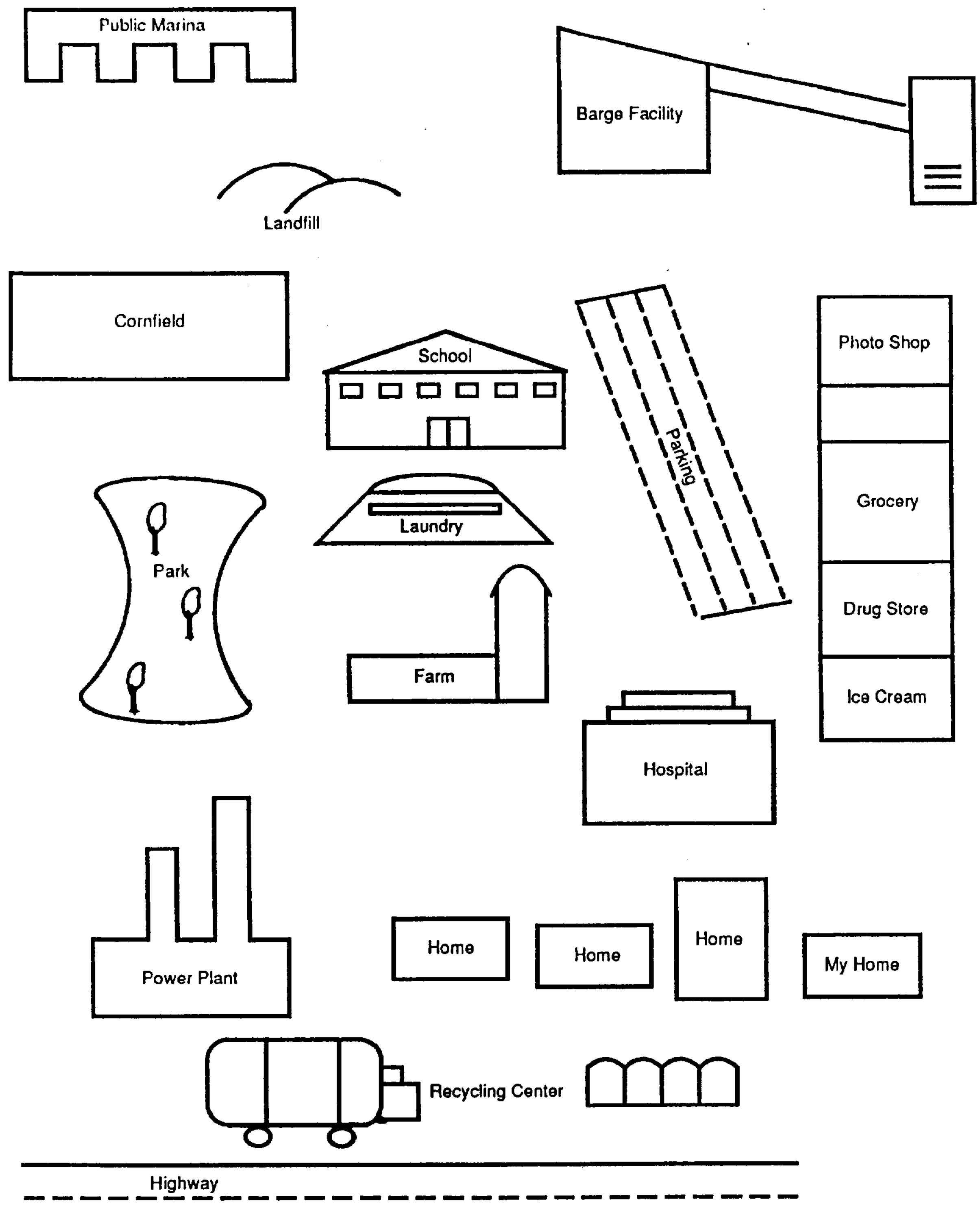
6. In a concluding discussion, help the class to understand that planning a community requires taking into account the present and future needs of many different people, as well as the environment.

Extension/ Evaluation

Have students examine the community in which they live. If they were community planners, what types of things would they change in the community? What would they add and/or what would they take away? Encourage students to use their imaginations and to consider the needs of people other than themselves. (Possible changes could include more natural spaces, a recycling center, or a new housing development. Students might also suggest tearing down dilapidated buildings or making parkland or playgrounds out of empty lots.)

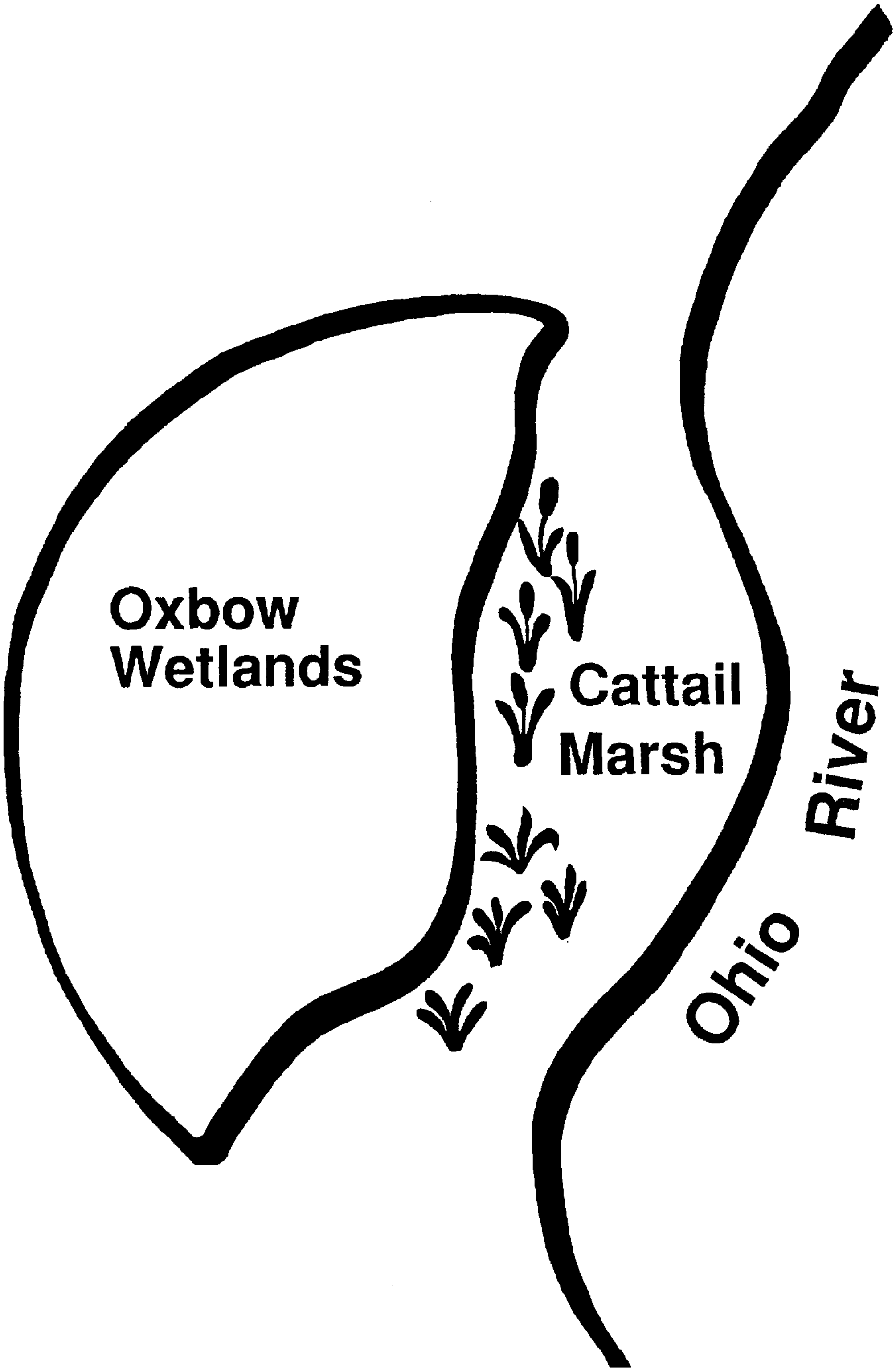
Community Landmarks

Cut out the following landmarks or design your own out of pieces of paper. Glue these onto your community.



Habitat

Glue this sample habitat on a large sheet of construction paper to begin your community land use plan. Or design your own original ecosystem, containing river, marsh, floodplain, or wetland habitat of your own choice!



D

Activity

Careers on the River

Objective
Students will learn about various river careers by developing brochures that describe and promote their own businesses.

Setting
Classroom

Duration
Several 40-minute class periods and time outside of class for research

Subject
Art, English, Social Studies

Skills
Application, Communication, Decision-Making, Description, Drawing, Media Construction, Reading, Research, Synthesis, Writing

Grade Level
6-12

Vocabulary
career

Background Information
Refer to Unit III, Section D-1.

Materials
- Library books and other reference materials.
- Paper and pen or pencil.
- Construction paper, scissors, and glue.

Procedure
1. Discuss with students various careers that are directly associated with the Ohio River. These might include working with locks, power plants, barges, water treatment plants, riverfront restaurants, commercial or recreational piers, or the U.S. Coast Guard.
2. Tell students to imagine that they have been given the opportunity to own a business on the river. Provide students with time to research different careers and choose their business.
3. Have students write and design a brochure that promotes their business. In the brochure, they should include:
   - The nature of the business and the service it performs.
   - The name of the business.
   - Where the business is located.
   - The types of job opportunities available at the business.

Procedure *(continued)*

- Some of the most outstanding features of the business. (Why would someone want to use this business, or why would someone want to work there?)
- How the business fits in with the natural environment of the area. (What type of recycling or pollution control does the business exercise, or how does the architecture of any buildings blend in with the landscape?)

4. Encourage students to make use of illustrations and other design elements to make their brochures attractive. For example, students might want to design maps indicating how to get to their businesses or draw pictures of their businesses in operation.
5. Display finished brochures on the bulletin board.

Extension/ Evaluation

Hold a "Career Day" where students take turns presenting their brochures and answering questions about their businesses posed by other students.

Invite local business people to your classroom to talk about their own careers and the benefits their businesses provide to the community. Encourage students to prepare questions in advance to help make the interview more productive. (See Appendix C, "Guidelines for Interviewing People.")

D

Activity

Whose Job Is It?

Objective

Through examining pollution problems and people's roles in society, students will learn that cleaning up the environment involves tradeoffs in people's time as well as money.

Setting

School grounds and classroom

Duration

One 1/2- to 1-hour period

Subject

Social Studies, Science

Skills

Observation, Discussion, Analysis, Synthesis, Problem-Solving, Small Group Work

Grade Level

2-6

Vocabulary

resources opportunity cost

Background Information

Refer to Unit III, Sections D-1 through D-5.

Materials

- Worksheets for each group with the headings: Who Can Help, Other Uses of Time, and Opportunity Cost.
- Pencil or pens.

Procedure

1. Find an unsightly area somewhere on the school grounds and point it out to students. Some possibilities are the playground, near the dumpster or trash cans, near the school cafeteria, or even certain hallways.
2. Back in the classroom, ask children to think who might be responsible for cleaning up the area (students, teacher, principal, custodian, parents, others).
3. Pick one of these potential "helpers" and discuss how this person could use his or her time other than cleaning up the area. For example, a teacher would have to give up class time to clean it up. Explain that in order to clean the environment, productive resources are required. If these resources are used to clean, they are not available to perform other useful work. The work that is unable to be performed is known as the "opportunity cost" of a clean environment.

Procedure *(continued)*

4. Break the class into small groups and give each group a worksheet with the headings as listed under "Materials." Ask students to fill in the worksheet for all of the people named in Step 3.

5. After students have finished with the worksheet, brainstorm with students to come up with some solution to the problem. (Possible solutions could be assigning cleanup to a particular person, dividing the cleanup detail equally among different people, establishing rules of behavior that prevent such messes from occurring in the future.) Discuss the pros and cons of each possibility.

Extension/ Evaluation

Have students investigate pollution problems in their school more comprehensively. Then, as a class, or again in small groups, have students formulate a list of rules that would apply to everyone in the school to reduce the costs of cleanup by reducing the amount of pollution generated.

Adapted with permission from: The Joint Council on Economic Education, Elementary Economist, Vol. 10, No. 3, Spring 1989.

D

Activity

Who Wants to Pay?

Objective

By conducting a simulation, students will appreciate the costs of pollution abatement and the complexity of the problem of who should pay for cleanup.

Setting

Classroom

Duration

1 hour

Subject

Mathematics, Science, Social Studies

Skills

Role-Playing, Computation, Communication, Evaluation, Interpretation

Grade Level

2-6

Vocabulary

tradeoff costs consumer

Background Information

Refer to Unit III, Sections D-1 through D-5.

Materials

- Pennies or small tokens to represent monetary units.
- Real candies or cutouts that resemble candies.

Procedure

1. Tell students that they are going to imagine that several of their classmates are manufacturers who produce a special type of candy. The rest of them will be consumers who enjoy eating this candy. The factories for these candies are located on the Ohio River and the production process uses thousands of gallons of river water that must then be dumped back into the river. (You might want to draw a rough sketch on the board showing how these factories are located in relation to the river and your community.)
2. Ask for volunteers or select four students to be the producers.
3. Tell students that the price of a piece of candy is set at two candies for a penny (or token). Distribute a penny or token to each consumer and equally distribute candies to each of the four producers (so that there are enough candies for each child to buy two).
4. Allow students to make their purchases. Have students observe that all producers have sold all of their candy.

Procedure *(continued)*

5. Call the producers together and ask for two of them to raise their price to pay for equipment to clean up the pollution flowing back into the river. The price for these producers is one candy for a penny.
6. Again distribute pennies to the consumers and candies to the producers. This time give fewer candies to those electing to control pollution; more to the polluters.
7. Allow students time to buy.
8. Contrast this outcome with the first round of buying.
   - Who sold more candy? Why?
   - Why did the consumers decide to buy from the polluting producers rather than the environmentally conscious ones?
   - How do you think the producers who bought the pollution control equipment felt?
   - As consumers, would you voluntarily pay more money for a product that caused less pollution? Why or why not?
9. Discuss with students alternatives to consumers or responsible producers bearing the cost of pollution control, such as taxing or fines.

Extension/ Evaluation

For an out-of-class assignment, have students list examples of social costs that occur as the result of consumption (overflowing trash containers, litter on the highway, overflowing landfills). Discuss alternatives for reducing these costs including voluntary efforts and actions of local governments. For example, local government agencies could encourage recycling by specifying that garbage would only be picked up if it was separated into recycling categories (newspapers, aluminum, glass, etc.).

You may wish to invite a business person and a local government official to discuss government incentives for reducing the social costs of pollution.

Adapted with permission from: The Joint Council on Economic Education, Elementary Economist, Vol 10, No. 3, Spring 1989.

D

Activity

To Develop or Not to Develop?

Objective Students will evaluate the impacts of local development projects, and weigh their positive and negative aspects.

Setting Classroom

Duration Two or three 40-minute class periods

Subject Economics, English, Social Studies

Skills Writing, Persuasion, Evaluation, Decision-Making, Communication, Application, Analysis, Discussion

Grade Level 6-9

Vocabulary economic

Background Information Refer to Unit III, Sections D-1 through D-4.

Materials

- Newspaper clippings.

Procedure

1. For several months (or longer) prior to performing this activity in class, collect newspaper clippings of development projects along the Ohio River and its tributaries, with an emphasis on projects that affect your community. Be sure to include some that are controversial. You may wish to have students "help" you with this preparation by encouraging them early on to begin bringing in clippings to add to your file.
2. Discuss some of these projects in class, bringing up such issues as:
   - Who does this project benefit and what are those benefits?
   - Who, if anyone, does this project harm?
   - What are the economic and environmental costs involved?
   - Do you think the benefits outweigh the costs?
3. Establish an interest in a proposed project that will impact the river environment near your community. This might be a floating restaurant, a marina, a riverfront housing development, or a new factory. Discuss in detail the issues raised above in Step 2.

Procedure

(continued)

4. If possible, invite a spokesperson for the development project (or an opponent, or both) to present his or her views. The class should prepare questions in advance that allow them to explore the issue in more depth than was possible from articles or news reports and their own discussion. Encourage students to remain as objective as possible until all the facts are in.

5. In a final discussion, try to come to a consensus as a class on whether you support or oppose the development activity. Allow dissenters to hold to their opinions if they choose.

Extension/ Evaluation

Have students write editorials expressing their views on the development project as if they were sending them to a school paper or local newspaper or magazine. Encourage them to present their arguments logically and systematically, and back up their points with concrete examples. You might also like to hold a classroom debate on the issue.

D

Activity

Pollution Detectives

Objective

Students will investigate pollution problems in their own community, learn about laws that affect these problems, and make decisions that involve weighing the costs and benefits of pollution cleanup.

Setting

Classroom and the community

Duration

One 1/2-hour class period preparation, several afternoons outside of class, and ample class time for student presentations

Subject

Government, Science, Social Studies

Skills

Listening, Investigation, Application, Synthesis, Recording Data, Discussion, Writing, Decision-Making, Communication, Problem-Solving, Brainstorming

Grade Level

7-12

Vocabulary

tradeoffs

Background Information

Refer to Unit III, Sections D-1 through D-5.

Materials

- Map of the community for display in the classroom.
- "Pollution detective" diaries or notebooks (students can make their own).

Procedure

1. Read students the paragraph below (you may wish to modify the text to the appropriate level for your class):

Once upon a time there were three curious teenagers. They were always asking why things happened and were not satisfied until they got an answer. One day toward dusk, they were walking home from school when one saw a river of curious substances flowing down the stream into the storm sewer. "Look at that!" shouted Jessie. "I wonder what it is," exclaimed Manuel. "It's blood," whispered Dina. The three of them walked closer. They saw that the mysterious fluids were actually the fluids of an old school bus and two automobiles left to rust next to a house. The "blood" was oil, gasoline, brake fluid, and battery acid. "Don't touch this stuff!" shouted Dina. "Those are hazardous substances!" "Why would the owner leave old vehicles there?" asked Manuel. "Let's find out."

Procedure *(continued)*

2. Ask the students to brainstorm possible reasons why the bus and cars were left in the yard. Have students consider who is affected by the problem and who should persuade the owner to remove the old bus and cars. Help students to understand that the fluid being drained into the sewer is imposing a potential hazard on many people.
3. Tell students that they are going to become "water pollution detectives" in their community. Their assignment is to seek out situations where environmental problems exist in their community which cause harm to water bodies or the community's water supply. They are to record their findings by writing paragraphs describing or drawing pictures of what they see, and locating the sites on a community map that is displayed in the classroom. (Be sure to caution students to obey "No Trespassing" signs and keep their distance from potentially hazardous substances.)
4. Each student should pick one problem from his or her investigation to research further and present to the class. His or her presentation should cover the following issues:
   - The reasons for the pollution.
   - Who is experiencing the negative effects of the pollution.
   - What should be done to solve the problem.
   - What laws, if any, cover the problem.
   - What it will cost to solve the problem.
5. After students have finished giving their presentations, have the class decide which problems should be solved first based on the relative costs and benefits derived from the cleanup.

Note: As an alternative to Step 3, in areas where student "sleuthing" might be difficult or dangerous, have students investigate national or international environmental problems in magazines or newspapers.

Extension/ Evaluation

If equipment is available, students may wish to develop a photo essay or videotape to accompany their presentation. For videotape projects, students might want to get together in pairs or small groups to focus on a single problem site.

You could further extend this activity to allow students to make presentations at a schoolwide assembly, a community meeting, or a meeting of a local environmental group.

Adapted with permission from: The Joint Council on Economic Education, Elementary Economist, Vol. 10, No. 3, Spring 1989.

Historic Influence and Implications of the Ohio River

Historic Influence and Implications of the Ohio River

This unit examines the influence of the Ohio River on the location and cultures of settlements in the area—from ancient times through the present. Activities in *Section A* investigate the lives of the ancient people who lived along the Ohio River, as determined by the archeologists who uncover their artifacts. Several activities focus on the culture of the Mound Builders, who used the Ohio River to implement a vast trading network.

Activities in *Section B* review the development of the Ohio River Valley since the arrival of European settlers. From the first flatboats carrying pioneers and their possessions to the huge barges carrying raw materials today, the Ohio River has served as a vital artery in the development of America's heartland. In three activities, students investigate the growth of a specific community along the river or its tributaries. Students examine both the economic development of these towns and the lives of the people who lived in them. In the activity "Watered Down History," students predict the fate of the river, and explore their roles in shaping its future.

A Ancient Settlements along the Ohio River

1 Paleo Indians—Times of Hit or Miss

The first humans along the Ohio River probably were small groups of nomadic hunters called Paleo Indians. They hunted the mastodons, mammoths, horses, and other large beasts that inhabited the area during the Ice Age. They did not form settlements, but followed the herds as they roamed. The only evidence they left were large flint blades apparently used as spear points for hunting.

The number of Paleo sites along the Ohio River is less than a hundred, and the time span of Paleo occupation is vast—several thousand years. (See Figure IVA-1.) Therefore, initial Ohio River settlement was random, sparse, and temporary. (See Unit I, Section A-2 for more information about the Ice Age.)

2 Archaic Indians—A Good Life on the River

As the vast ice sheets melted, Indians were forced to adapt to a changing environment. The large beasts became extinct, and Indians roamed less and relied more on the environment around them for food. In the Ohio River Valley, this meant a diet procured from the newly developing woodlands and from the many lakes and rivers left by the melting glaciers.

The first people to live in permanent settlements along the Ohio River were the **Archaic Indians**. Their population was scarce, including only several hundred camps and small villages along the river. The Archaic Indians occupied the area for several thousand years. (See Figure IVA-2.)

Archeologists have found the remains of several Archaic sites. At these sites they find **artifacts**, which are the articles left behind by the ancient culture. By carefully examining these artifacts and noting the context in which they are found, archeologists are able to develop theories about how the Indians lived. Archeologists have found a variety of flint blades among Archaic artifacts, perhaps indicating there were many different groups of Archaic people along the Ohio

River. Specialized stone tools have also been found, which suggests permanent settlements and the use of forest products.

Archaic sites are often characterized by large deposits of freshwater shellfish and large caches of burned acorns. These findings signify the Indians' reliance on food sources associated with a river environment, which were more reliable than nomadic hunting.

3 The Mound Builders—Aliens or Ancestors?

When early European settlers came to the Ohio River Valley, they were astonished at what they saw. Large earthworks in the form of mounds, several miles long, dotted the landscape. Over a thousand mounds were located in valley areas along the Ohio River, on hilltops overlooking the river, and far up major tributaries. (See Figure IVA-3.) Early excavations showed the majority of these mounds to be burial sites containing exquisitely carved pipes, beautiful jewelry, and carefully worked copper ornaments. The Europeans, blinded by their prejudice against the Indians around them, theorized that these artifacts must be the work of a glorious ancient people who bore no relationship to the "savages" who then occupied the valley. This "lost race" was thought to be the lost tribe of Israel, or perhaps the remains of the great culture of Atlantis.

Archeologists have disproved these early theories, and shown these artifacts to be the work of ancestors of Indians who occupied the valley at the time the Europeans came. The mounds were built by two early groups of ancient Indians: the **Adena** (700 **B.C.** - 400 **A.D.**) and the **Hopewell** (200 B.C. - 500 A.D.). These Indian artifacts represented a high state of cultural development characterized by several significant developments. The Mound Builders were the first Ohio River Valley Indians to use pottery, with which to cook and store food. They also began cultivating certain wild plants. This early agriculture supplemented the hunting and gathering of forest resources, which dwindled as the population increased. The Mound Builders also introduced the burying of high-status dead with extravagant grave goods and burial mounds.

Archeologists have uncovered more than 200 Adena sites in southern Ohio and adjacent areas of West Virginia, Pennsylvania, Kentucky, and Indiana. The Adena Indians made pottery, smoked strong tobacco in tubular pipes, and lived in villages of from two to five houses. They buried their dead in cone-shaped mounds, some as high as 70 feet. The largest Adena mound is located in Moundsville, West Virginia.

The Hopewell Indians, who appeared later than the Adenas, are known for the variety and beauty of the objects found in their burial mounds. Certain concentrations of their burial mounds and ceremonial earthworks, usually located where two or more rivers join, are speculated to be centers of a vast trade network that utilized river transportation (dugout canoes) to access exotic materials for grave offerings. Hopewellian mounds have yielded artifacts made from obsidian and grizzly bear teeth from Yellowstone Park in Wyoming, marine conch shells from the Gulf of Mexico, copper nuggets from Isle Royale near Canada, and mica sheets from the Blue Ridge Mountains. In turn, materials native to the Ohio River Valley—flint, freshwater pearls, and pipestone—have been found in ancient archeological sites in other parts of the United States.

Archeologists believe the Hopewellian culture was hierarchical, with elaborate mound burial reserved for priests, chiefs, and other important people. The vastness of some earthworks suggests the existence of valued "experts" who taught skilled crafts and directed construction of the burial mounds. As evidence of this, a recent analysis showed that Hopewellian mounds located as far as 14 miles apart were perfectly aligned.

The Hopewell relied on small game, fish, and some agriculture for their sustenance. Archeologists believe that these Indians began selecting wild plants for favored traits. For example, they collected the largest seeds from certain wild plants and planted them. They would then use the plants grown from these large, cultivated seeds. The Hopewell were so successful at feeding themselves that their population grew substantially. Archeologists estimate that one Hopewell settlement along the Illinois River supported 50 people per square mile, a population denser than the one that currently occupies this area.

4 Fort Ancient Indians—Early River Farmers

Late ancient Ohio Indians, including the **Fort Ancient** Indians (1200 A.D.-1500 A.D.), lived in large towns along the Ohio River and other major streams. They supplemented hunting (now with bow and arrow) and gathering with corn agriculture. The population apparently increased greatly with this new and plentiful food supply.

Settlements usually occurred in valley areas where two or more rivers joined, although hilltop and inland sites are also common. (See Figure IVA-4.) The artifacts found at some late ancient sites suggest that there may have been conflicts between these tribes.

Figure IVA-1. Ancient Indian sites.

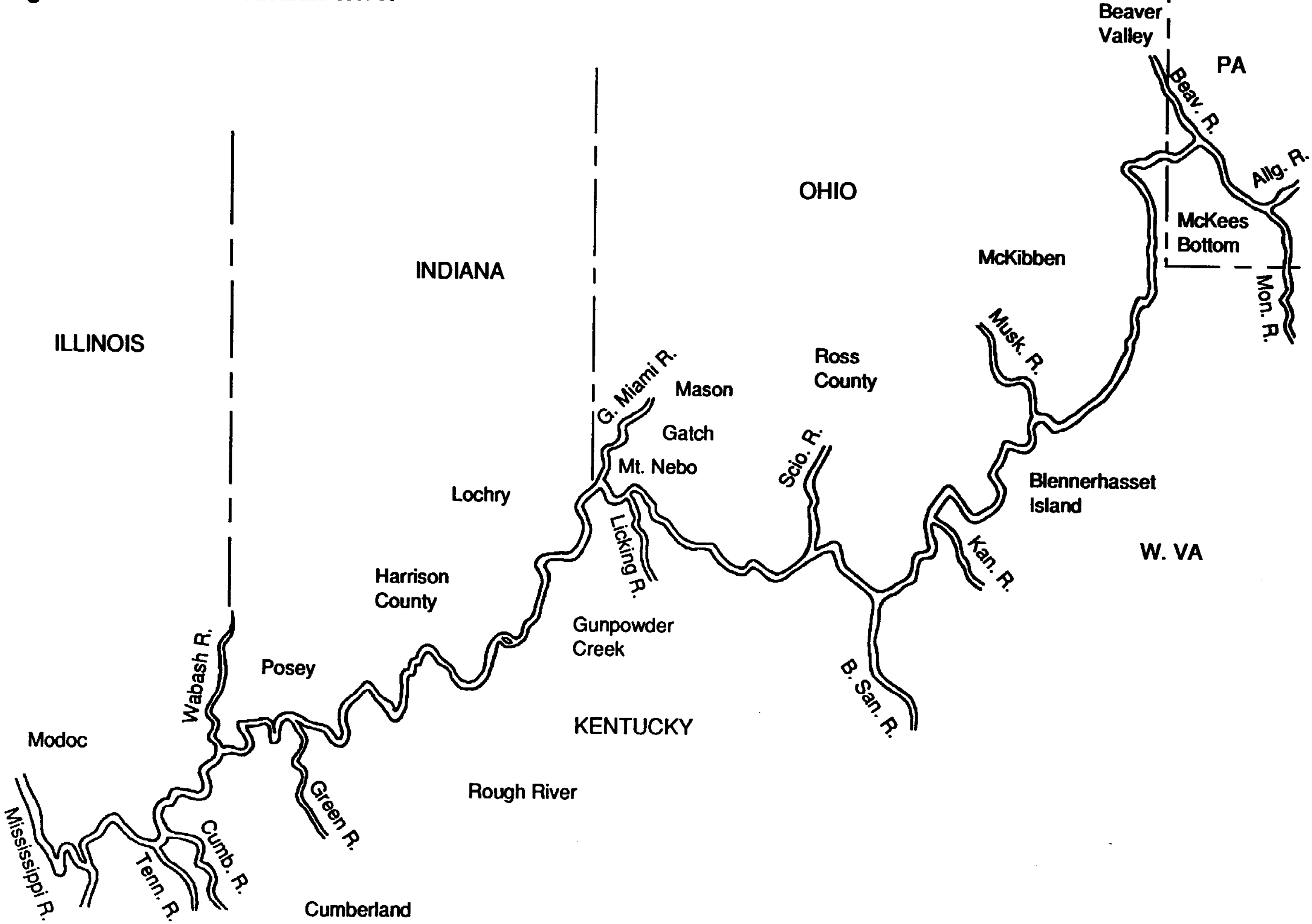
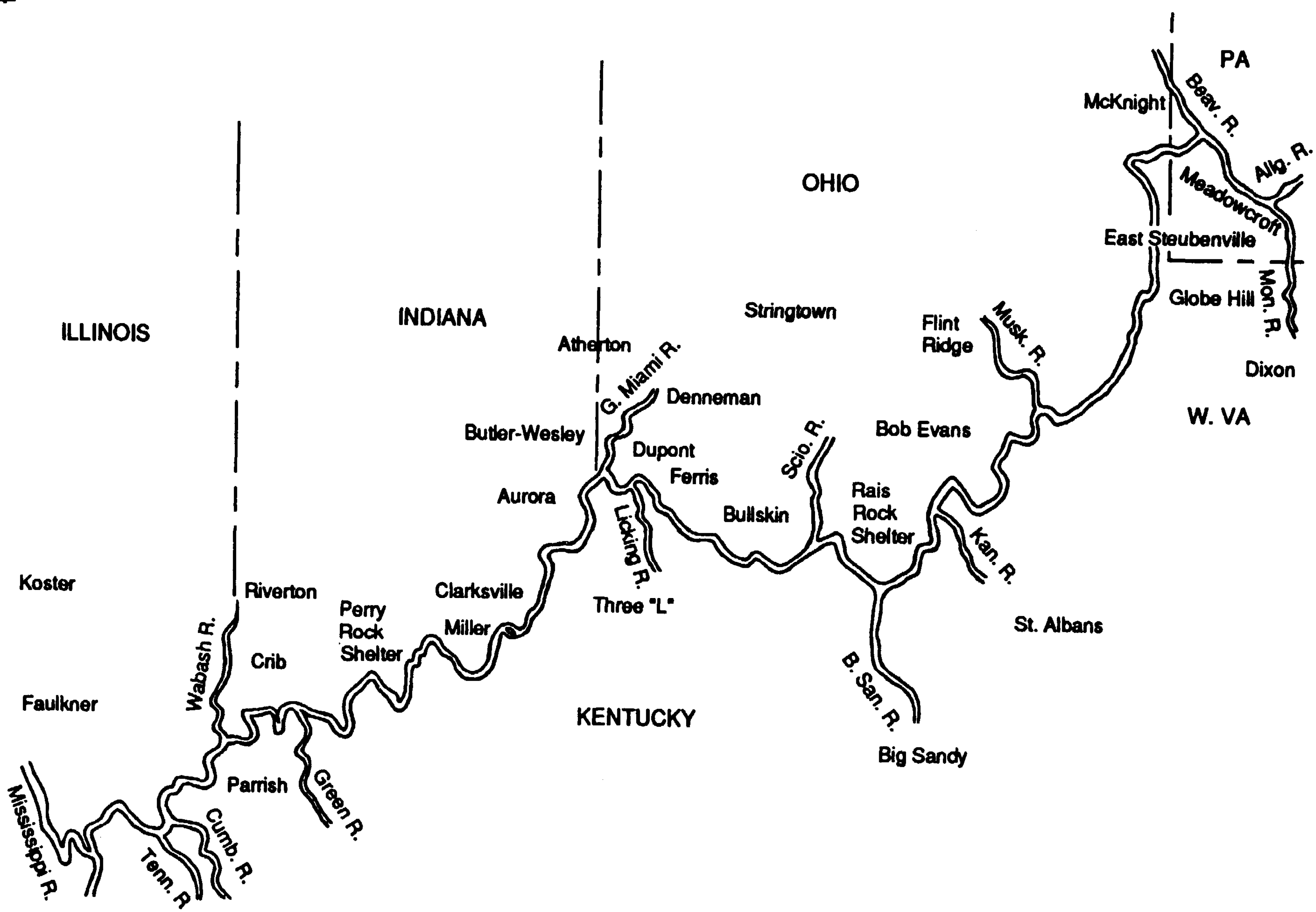


Figure IVA-2. Ohio River Archaic sites, 5000 B.C. - 1000 B.C.



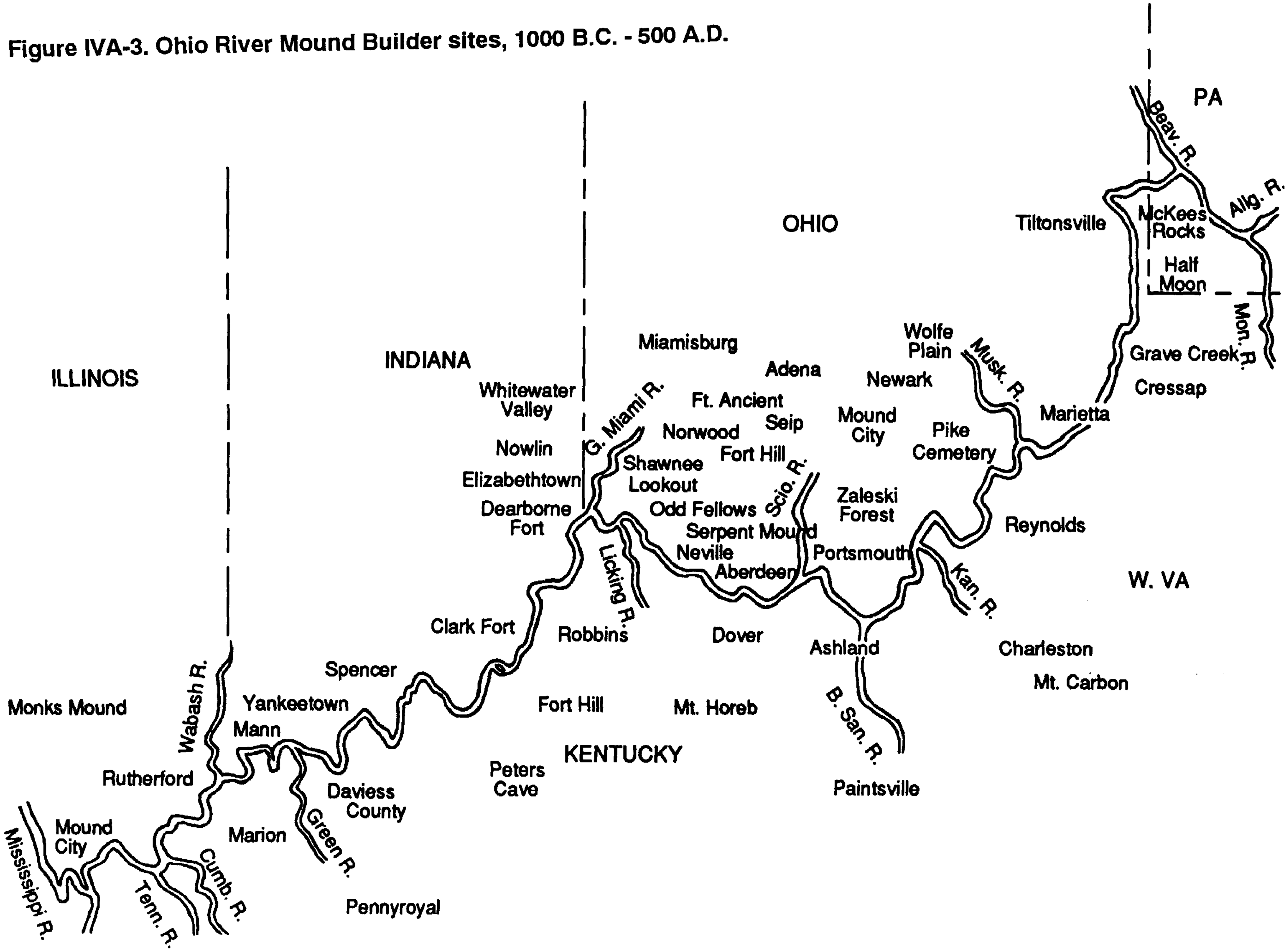
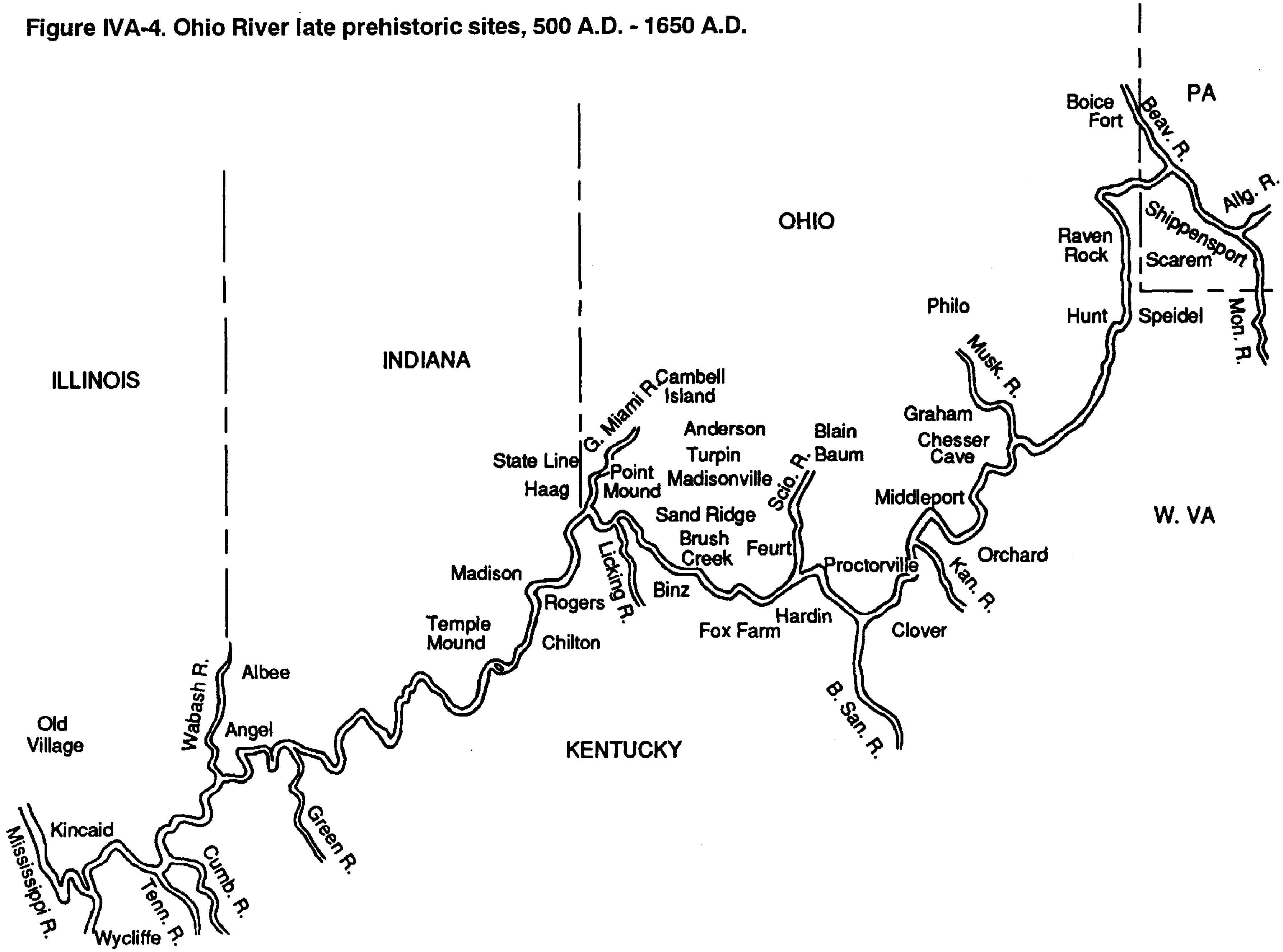


Figure IVA-3. Ohio River Mound Builder sites, 1000 B.C. - 500 A.D.

Figure IVA-4. Ohio River late prehistoric sites, 500 A.D. - 1650 A.D.



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*Archeological Sites:**

For more information concerning these and other sites, contact your state archeological society or historical society.

Illinois

Cahokia Mounds Sate Park, reached from East St. Louis. A mound group including the largest earthen mound in the United States.

Center for American Archeology, Kampsville. Archeological site and program that offers tours for students of all ages, and a field school for middle and high school students. Also provides teacher training programs. Telephone 618-653-4316 for more information.

Resources ***(continued)***

Dickinson Mounds Museum of the Illinois Indian, Havana. A Hopewellian burial mound and ancient village site.

Indiana

Angel Mounds State Park, Evansville. An extensive mound and village site.

Mounds State Park, Anderson. Nine Hopewellian mounds.

Kentucky

Adena Park, near Lexington. Adena circular earthwork ceremonial center.

Ancient Burial City, Wickliffe (reached from Cairo, Illinois). A private commercial exhibit with mound groups and village patterns.

Blue Licks Battlefield State Park, Blue Licks (reached from Lexington). A salt spring used by Paleo-hunters and a Fort Ancient culture village site.

Ohio

Campbell Mound, Columbus. An Adena culture mound.

Flint Ridge Quarry, Zanesville. The most famous aboriginal flint source in the eastern United States. Museum at site.

Fort Ancient, near Lebanon. Hopewellian earthworks and a later settlement by the Fort Ancient people. Museum.

Fort Hill State Memorial, reached from Hillsboro or Chillicothe. Hopewellian ceremonial and defensive earthworks. Museum.

Miamisburg Mound, Miamisburg. A large Adena mound.

Mound City Group National Monument, Chillicothe. A burial mound and ceremonial center for the Ohio Hopewell people. Artifacts are considered spectacular. Museum.

Newark Earthworks, Newark. A large Hopewellian earthworks complex, of which little remains.

Seip Mound, Bainbridge. A group of Hopewell burial mounds, with a circular earthwork over a mile in circumference. Museum.

Resources *(continued)*

Serpent Mound, Locust Grove. A quarter-mile-long effigy mound of a snake with an egg in its mouth, attributed to the Adena. Considered one of the greatest ancient wonders in the present United States.

Shawnee Lookout, Hamilton County District Park, Western Cincinnati. Hopewellian earthworks and village sites from various cultures and a small interpretive museum.

Story Mound, Chillicothe. A reconstructed Adena mound that is visible from the street.

West Virginia

Grave Creek Mound State Park, Moundsville. The largest known Adena mound in the center of at least 47 mounds. Museum.

Museums

Behringer-Crawford Museum. De Vou Park, Kentucky.

Big Bone State Park. Union, Kentucky.

Cincinnati Museum of Natural History. Cincinnati, Ohio.

*List taken from: Brennan, L.A., Beginner's Guide to Archeology (Harrisburg, PA: Stackpole Books, 1973.)

A

Activity

Archeological Sites

Objective

Students will learn to recognize the names of the three Indian groups who inhabited the Ohio River Valley in ancient times and to identify contemporary civilizations in other parts of the world. They will be able to locate on a map the sites of six ancient Indian habitats in Hamilton County, Ohio.

Setting

Classroom

Duration

1-hour period, or two 1/2-hour periods

Subject

Social Studies

Skills

Map Reading, Discussion, Comparing Similarities and Differences, Application, Analysis, Generalization

Grade Level

5-8

Vocabulary

Adena Hopewell Fort Ancient B.C. A.D.

Background Information

Refer to Unit IV, Section A-3.

Materials

Part 1

- Archeological Sites—Activity Sheet.
- Map of Ancient Indian Sites.
- Crayons or colored pens.

Part 2

- Archeological Sites—Timeline handout.
- Blank Timeline.
- Crayons or colored pens.

Procedure

Part 1

1. Explain to students that there were three main groups of ancient Indians who inhabited Hamilton County, Ohio, and the Ohio River Valley in general. Briefly describe the concept of archeological sites, and how researchers uncover the remains of ancient cultures. Tell students that the Ohio River Valley is considered to be one of the richest archeological regions in the United States.

Procedure

(continued)

2. Pass out the Map of Ancient Indian Sites and the Activity Sheet handouts.
3. Tell students to complete the map as directed and answer the questions at the bottom of the sheet. Students who are unfamiliar with the Cincinnati area may require teacher assistance with this step.
4. When students have finished, review the maps with the entire class. Discuss students' answers to the questions.
5. If available, show students pictures of these sites, and of artifacts taken from them.

Part 2

1. Explain to students that these Indian groups were not the same as those found by early European settlers, but were their ancestors.
2. Pass out the Archeological Sites—Timeline handout and the blank Timeline. Review with students the concept of a timeline. Explain the concepts of B.C. and A.D. Have students locate the dates on the timeline.
3. Discuss with students what else was occurring in the world during the time of the ancient Ohio Valley Indians. Point out the contemporaries of each of the three Ohio Indian groups. Note that the Adena and Hopewell Indians inhabited the Ohio River Valley for much of the same time.

Extension/ Evaluation

Divide the class into three groups, and have students research each of the three Indian groups. Students should report back to the entire class with pictures, etc.

Ancient Indian sites abound throughout the entire Ohio River Valley. Take students to visit one of the ancient Indian sites in Cincinnati, or near their own community. If no site is convenient, visit one of your local museums that displays ancient Indian artifacts. (See the Unit IV, Section A, Resources for a list of sites and for information about the Center for American Archeology in Kampsville, Illinois.)

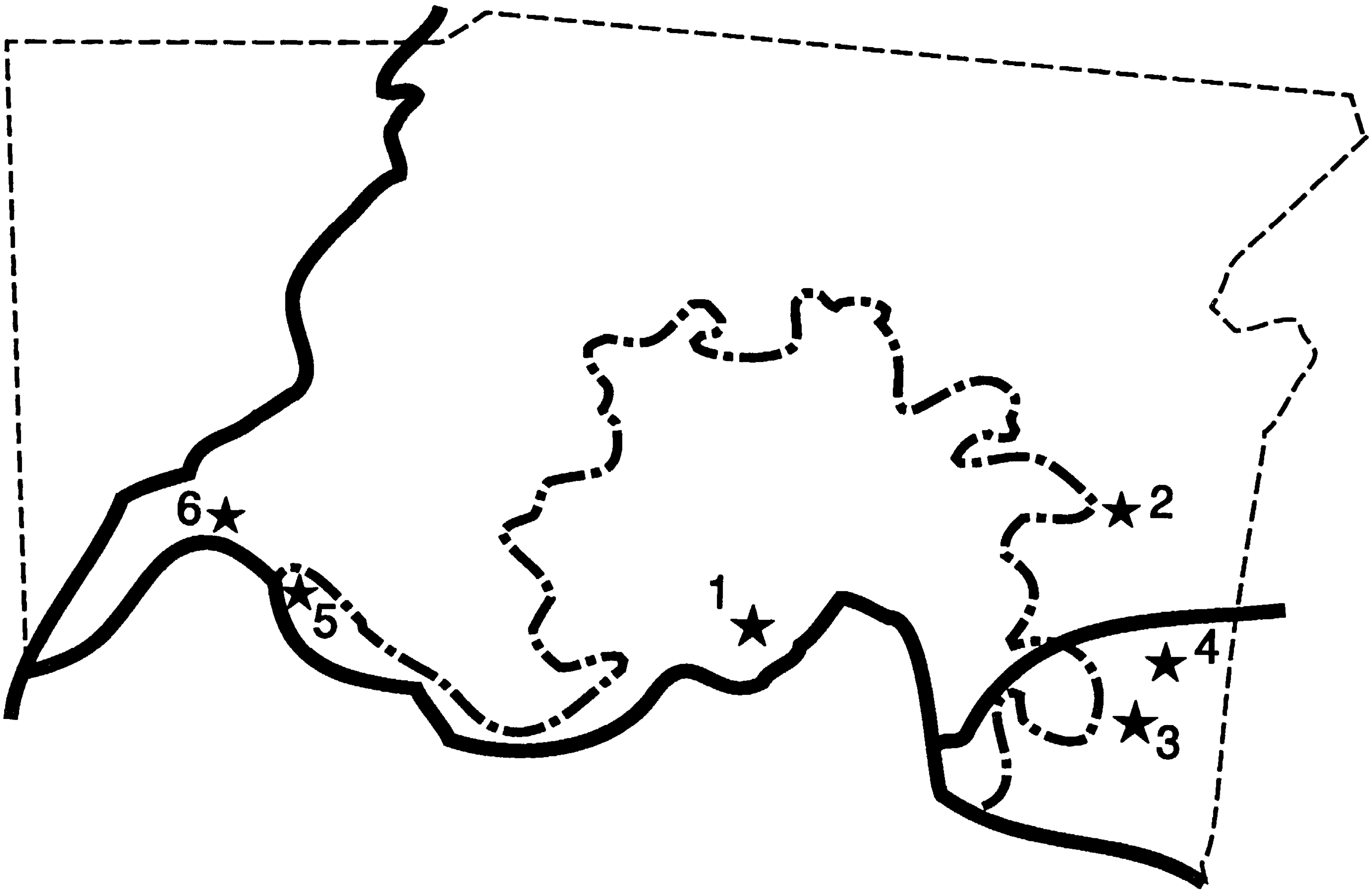
Extension/ Evaluation

(continued)

Have students pick a period of time in ancient history. This could be a single year, or a period of a few hundred years. Tell students they are the editors of a world yearbook, which is supposed to chronicle the events of that period of time throughout the world. Have students pick parts of the world they are interested in, and research what was going on there in this time frame. When students have completed their research, have them write stories describing what occurred in their part of the world. Have students compile these stories and prepare a yearbook for publication. Encourage students to be creative—to draw pictures, use art work, and write creative, first-person accounts of how people lived.

Adapted with permission from: Regina, K., Cincinnati: An Urban History (Cincinnati, OH: Cincinnati Historical Society, 1989).

Map of Ancient Indian Sites



Archeological Sites—Activity Sheet

Your teacher will give you a map that shows a number of major archeological sites in Hamilton County, Ohio. The chart below gives information about these sites. Follow the directions below to fill in the map. Then answer the questions that follow.

Number On Map	Location On Map	Dig Years	Who Lived There?	What Was Found
1	Fifth & Mound Sts. (downtown)	1840s	Adena	stone tablet with symbols
2	Mariemont (Madisonville)	1880s and 1980s	Fort Ancient	village site, storage pits, burials
3	Anderson Township (Turner Works)	1880s	Hopewell	monster sculpture
4	Newtown (Turpin Farm)	1940s	Fort Ancient	village and burial mounds
5	Sayler Park	1950s	Adena	bones and artifacts
6	Cleves (Miami Fort Shawnee Lookout)	1970s	Hopewell	structure of a fort

Complete the map by:

- Labeling the states of Ohio, Kentucky, and Indiana, and Hamilton County.
- Labeling Ohio River, Great Miami River, and Little Miami River.
- Use a symbol or color to identify each site as Adena, Hopewell, or Fort Ancient.
- Draw a picture to represent what was found at each site.
- Color in the area that is Cincinnati.

Now answer these questions:

1. Do you notice any pattern to the location of sites?
2. What would you find if you visited these sites today?
3. Are any of these sites close to where you live?

Archeological Sites—Timeline

Your teacher will pass out a blank timeline. Using crayons or a colored pen, show the dates listed below. If the time given is for a period of time, for example, 1000 B.C. to 800 B.C., draw a line, not a dot. Use different colors for each line. Next to each time you find on the timeline, write in the words given on the list.

Time	Words to Write on Timeline	What Happened Then
1 A.D.	Jesus Christ	Jesus Christ was born. He founded the Christian religions.
1000 to 800 B.C.	Pharaohs, Egypt	The last of the great Pharaohs ruled in Egypt.
700 B.C. to 400 A.D.	Adena	The Adena Indians lived in the Ohio River Valley.
490 B.C.	Marathon, Greece	In ancient Greece, a messenger ran from the city of Marathon to the city of Athens to tell of a great military victory. This was the first "marathon."
753 B.C. to 476 A.D.	Romans	The Roman Empire grew from the city of Rome to most of the area surrounding the Mediterranean Sea.
200 B.C. to 500 A.D.	Hopewell	The Hopewell Indians lived in the Ohio River Valley.
500 to 100 B.C.	Kush, Africa	In Africa, the Kingdom of Kush developed extensive trade routes across northeast Africa.
560 B.C.	Buddha	In Nepal, Buddha was born. He taught people that they must lead a moral life.
100 to 300 A.D.	Mayans	In Mexico and Central America, the Mayan Indians developed hieroglyphic writing and a complex calendar.
100 to 300 A.D.	Paper, China	Paper, made from vegetable fibers, was invented in China.
570 A.D.	Muhammad	Muhammad was born in Arabia. He founded the religion of Islam, which means submission to the will of God.
986 A.D.	Vikings	The Vikings came to North America.

Archeological Sites—Timeline

Time	Words to Write on Timeline	What Happened Then
1200 A.D. to 1650 A.D.	Fort Ancient	The Fort Ancient Indians lived in the Ohio River Valley.
1400 to 1500 A.D.	Incas	The Inca Indians expanded from Peru and built a prosperous empire along the western coast of South America.
1492 A.D.	Columbus	Christopher Columbus arrived in the "New World."

Timeline

1000 B.C.
900
800
700
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500 A.D.

A

Activity

Artifacts from the Past

Objective

Students will be able to define the concepts of culture and artifacts, identify key artifacts of the Hopewell culture, and recognize some potential artifacts of their own culture.

Setting

Part 1, classroom; Part 2, classroom and outdoors

Duration

Part 1: one 40-minute period; Part 2, two 40-minute periods

Subject

Social Studies

Skills

Inference, Comparing Similarities and Differences, Analysis, Discussion, Small Group Work, Recognition, Description, Generalization, Observation, Visualization

Grade Level

3-4

Vocabulary

archeologist artifact Hopewell

Background Information

Refer to Unit IV, Sections A-1 through A-3.

Materials

- Hopewell Indian Artifacts handout.
- Artifacts from the Past chart.

Procedure

Part 1

1. Explain to students the concept of archeological digs.
2. Pass out the Hopewell Indian Artifacts handout and Artifacts from the Past chart. Tell students that these artifacts were found by archeologists. These objects were all used by the Hopewell Indians, who lived in the Ohio River Valley almost 2,000 years ago, around the time of Jesus of Nazareth. Have students complete the chart. Students may work individually, or in small groups.
3. Discuss the students' charts. If available, show the class additional pictures of Hopewellian artifacts. Ask students:
   - What do all these things tell us about the Hopewell Indians?
   - How do these artifacts compare to things we use today?

Procedure *(continued)*

Part 2

1. Have students think more about artifacts and their own culture. Ask students:
   - Many years from now, how could archeologists know what our culture was like?
   - What is our culture like? What kinds of clothes do we wear? What do we eat? What do we play with?
   - Which objects show this?
2. Have students draw up a list of artifacts that would describe their own culture to an archeologist in the year 3000.
3. Have students bring in some of these things, as appropriate. Using a box or suitable container, make a time capsule containing these artifacts and bury it.

Extension/ Evaluation

Take the class to visit a museum or archeological site listed in the Resources for Unit IV, Section A. Have students make a list of what they see. When they return to class, ask them what they think the Indians used the artifacts for.

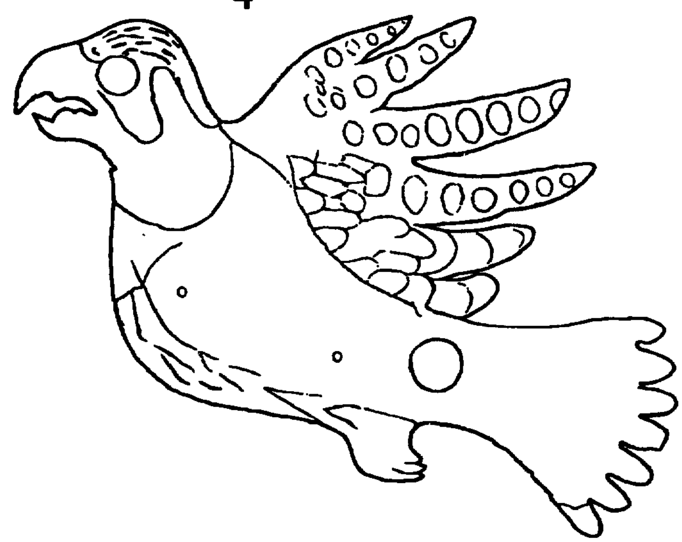
Adapted with permission from: Regina, K., Cincinnati: An Urban History (Cincinnati, OH: The Cincinnati Historical Society, 1989).

Hopewell Indian Artifacts

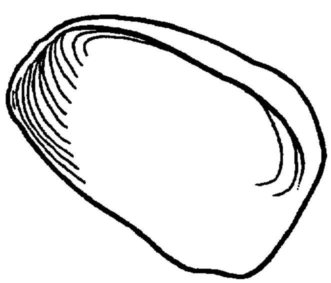
1

2

4



3



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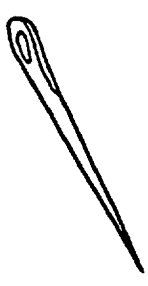

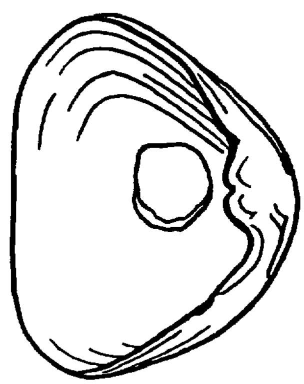

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7

Artifacts from the Past

Your teacher will hand out drawings of common Hopewell Indian artifacts. As you study the artifacts, pretend to be an archeologist. Fill in the chart below.

Artifact Number	What is it?	What is it made of?	What was it used for?
1			
2			
3			
4			
5			
6			
7			

These clues can help you complete the chart.

- Is it a falcon, a needle, an ax, a shell, a spear point, a pot, a pipe?
- Is it made of: animal bone, copper, clay, mica, stone (flint), shell, obsidian?
- Next to the picture of each artifact, list three words that describe it. Think about what its texture, size, shape, color, and weight might be.

A

Activity

Let's Prepare an Ancient Indian Feast

Objective

Students will experience a connection to their local environment by preparing a meal made from wild local foods. They will compare this diet to that of the ancient Indians who inhabited the Ohio River Valley.

Setting

Classroom, preferably in a kitchen

Duration

One 40-minute period to plan the feast, 1 1/2 hours to prepare and eat it

Subject

Health, Social Studies

Skills

Discussion, Cooking, Application, Comparing Similarities and Differences, Generalization, Small Group Work, Measuring

Grade Level

4-8 (K-3, if food is prepared for the children)

Vocabulary

Archaic Adena Hopewell

Background Information

Refer to Unit IV, Sections A-1 through A-3.

Materials

- *Stalking the Wild Asparagus*, by Euell Gibbons (New York, NY: D. McKay Company, 1964).
- Fresh foods that were native to the Ohio River Valley in ancient times. These include cracked corn, whole nuts, fresh oysters, leafy lettuce, stew meat, whole fresh fish, berry juice, and turtle soup.
- A stove or hot plate.

Procedure

1. Explain to students that the ancient Indians who inhabited the Ohio River Valley—the Archaic, Adena, and Hopewell Indians—lived in the woods and used the surrounding fields, streams, and forests as their supermarket. Discuss the types of foods these tribes might have found. Suggest that students prepare a feast of wild foods.
2. Have students look at Euell Gibbon's book and decide which foods they would like to roast, fry, or boil.

Procedure *(continued)*

3. Have students decide who will bring in the various foods. The teacher may want to take responsibility for this.
4. Prepare the feast as planned.
5. As students prepare and eat the feast, have them discuss their reactions to the foods they are eating. Ask them to consider ways in which their own diets are affected by where they live.

Extension/ Evaluation

Have students research the diets of each of the three Indian groups discussed and report to the class. How are they different and alike?

Have students research specific edible plants and animal species native to the Ohio River Valley.

As part of a food or nutrition class, have students evaluate the healthfulness of the ancient Indian diet. What does this diet suggest about the lives of the ancient Indians?

Check local recreation commissions, natural history museums, or nature centers to see if they are offering programs in either wild foods or Indian life.

A

Activity

Who Were the Mound Builders?

Objective Students will be able to describe the cultures of the Adena and Hopewell Indians and will develop an appreciation of their achievements. Students will understand how these Indian groups were viewed by early European settlers of the Ohio River Valley.

Setting Classroom

Duration Two 40-minute periods

Subject Social Studies, History

Skills Description, Discussion, Researching, Reporting, Observing, Analyzing, Reading, Listening, Public Speaking, Comparing Similarities and Differences

Grade Level 9-12

Vocabulary Adena Hopewell

Background Information Refer to Unit IV, Section A-3.

Materials

- A map of the United States.
- Library books.

Procedure

1. Describe the mounds seen by the early European settlers of the Ohio River Valley. Tell students about the theories of the settlers, who thought that the mound-building Indians were a lost master race. Explain that the mound builders were members of two groups, the Adena and the Hopewell Indians. These Indians were the predecessors of the Indians of colonial days. Ask students:
   - What other theories could the settlers have invented to explain the mounds and artifacts they saw?
   - Why did people choose to believe the "lost race" theory?

Procedure *(continued)*

2. Explain the concept of archeological digs. Show students pictures of Adena and Hopewell artifacts. Examples can be found in the books and magazines listed in the resources to Section IVA. Tell students briefly about the Adena and Hopewell Indians.

3. On a map of the United States, point out where the mound builders got the materials for their artifacts. Be sure to mention that the Ohio River Valley mounds contained deposits of marine conch shells from the Gulf of Mexico, copper nuggets from Isle Royale near Canada, obsidian and grizzly bear teeth from Yellowstone National Park, and mica sheets from the Blue Ridge Mountains. Ask students:

   - How did the mound builders get these materials?
   - How might they have traveled to these locations?

Point out that pipestone, freshwater pearls, and flint from the Ohio River Valley have been found at ancient archeological sites throughout the United States. Discuss the notion of trade routes, emphasizing the vastness of the mound builders' trade network.

5. Divide the class into groups that will research various aspects of the mound builders' culture. Topics might include food and diet, trade, artifacts, and religion.

6. Have students report to the class about their findings. Encourage students to report creatively: reconstruct artifacts, build models of burial mounds, write first-person accounts of life as an Adena or Hopewell Indian.

7. Take students to visit one of the Adena or Hopewell archeological sites near them. If no site is available, visit a museum that displays artifacts of the mound builders. See the Resources for Unit IV, Section A.

Extension/ Evaluation

Have students write a letter to the editor of a nineteenth century Ohio River Valley newspaper. Students should argue against the "lost race" theory that was then popular, and tell about the cultures of the Adena and Hopewell Indians.

B Settlement from the Europeans to the Present

1 Ohio River Indians (17th - 19th Century)—Refugees and Fugitives

When the first European settlers came to the Ohio River Valley, they found the region curiously empty of inhabitants. Gun-bearing Iroquois Indians had driven out other tribes in order to monopolize the fur trapping in Ohio.

When the Iroquois left Ohio, the Miami, Wyandotte, Shawnee, Delaware, and other Indians returned. They located their villages far up tributaries and streams to avoid the explorers, trappers, soldiers, and warriors who traveled on the river. (See Figure IVB-1.)

2 Pioneer Settlements—The River Is the Roadway

The frontier period saw hundreds and then thousands of American pioneers travel down the "Great Westward Flowing River"—the Ohio. Most pioneers settled first along the Ohio River itself, then later, further inland up the tributaries or further west beyond the Mississippi. Most settlers chose their settlements based on geographical and safety factors. Major cities and towns usually grew up where the Ohio River joined with one of its tributaries, and where the United States military established a fort to defend settlers against Indians. There are exceptions, however. For example, Louisville and Steubenville have no second river; there is no major town at the mouth of the Wabash River; and a number of smaller cities had no military post in the early days. (See Figure IVB-2.)

To reach settlements, many pioneers traveled downstream on large, unwieldy flatboats packed with their worldly possessions—furniture, dishes, farm animals, and more. To go upstream, they relied on barge-like keelboats, which they powered by pushing long poles into the river bottom. Sometimes crew members reached overhead for hanging willow branches, which they pulled on to move forward.

By 1792, a river packet—an elaborate keelboat—was making scheduled, 30-day trips between Cincinnati and Pittsburgh. Flatboats, crammed with crockery, cutlery, tinware, and clothes, were traveling between settlements selling household goods like floating general stores.

In 1811, the first steamship, the *Orleans,* was launched on the Ohio River and a new era was born. Huge shipments of pork, whiskey, cheese, flour, and other products made their way on the swift new boats to places like Pittsburgh and New Orleans. During the height of the steamboat era, American inland ships carried more tonnage than all the vessels of the British Empire's merchant fleet.

3 Early Industries Develop—Making the Most of Local Resources

Despite the improvements in river transportation, farmers in the Ohio River Valley, particularly those inland, had difficulty transporting their products to markets. Stories abounded of farmers whose grain lay rotting in the fields. The settlers found two solutions to this problem. The first was an elaborate system of canals which some states built to link inland areas to the Ohio River. The canals helped considerably, but travel along them was difficult. Boats were pulled at a speed of 2 to 3 miles per hour by horses and mules located on the embankment. Cabins on deck were small, cramped, and plagued by the mosquitoes that thrived in the canals. Malaria was commonplace.

The second solution was to convert the grain into flour and meal, which could then be fed to hogs or distilled into whiskey. This reduced the volume that needed to be shipped. The idea caught on, and before long almost every town in the valley had at least one grist mill, one distillery, and one slaughter house. Cincinnati developed a large meat-packing industry, earning it the nickname "Porkopolis." Meat, and the large amounts of whiskey and flour the city produced, allowed Cincinnati to become the first industrial metropolis in the west.

While most settlers earned their living on family farms, others began developing small industries. Towns developed economies based on local resources: Pittsburgh's steel industry relied on nearby iron ore and coal. In Zanesville, Ohio, pottery manufacturing made use of local clay deposits, and in Louisville, Kentucky, grains and forests were used to produce bourbon and baseball bats. Other developments were more circumstantial. A variety of immigrant groups arrived and settled in specific areas, bringing with them high-level skills needed for new industries, such as beer brewing and glass making.

4 Later Industrial Development—A Shift to the West and North

After the Civil War, the Ohio River Valley saw dramatic changes. With the expansion of the United States, the grain-growing centers shifted westward, taking agriculturally dependent industries with them. The meat packing capital of the country changed from Cincinnati to Chicago, and companies that made farm machinery were surpassed by larger companies in the west. Nevertheless, although agriculture-related industries were no longer the largest in the Ohio River Valley, corn, wheat, cattle, and hogs continued to play a significant role in the region's economy.

Another major shift was brought about by the country's increased reliance on railroads over river transportation. Railroads, and later roads, could better reach into inland areas, and were not as vulnerable to weather conditions. Railroads were constructed in the northern section of the region, because builders preferred the flat plains of the Lake Erie area to the rolling hills of the Ohio River Valley.

Since the railroads allowed greater access to inland resources, new areas could be developed. In the 1870s, John D. Rockefeller started the Standard Oil Company in Cleveland, Ohio, close to rich petroleum deposits. The iron ore and coal found in the northern regions of Ohio and Indiana fueled the development of great steel-making centers in the north. Gradually, the industrial focus of the region shifted from the towns along the Ohio River to the new industrial cities along the Great Lakes—Cleveland and Toledo, Ohio; and East Chicago and Gary, Indiana. These developing industrial centers served as magnets for new waves of immigration from the East.

Despite these changes, the Ohio River Valley maintained its status as an important industrial center. Smaller companies grew into larger ones, based upon the original industries of the region. One company, for example, began by using the by-products of Cincinnati's meat packing industry to make soap.

Today, the river that Thomas Jefferson once called "the most beautiful river in the world" continues to play an important role in the area around it. It serves as a major resource for leisure and recreational activities and remains a vital artery for the region and the country. A 1983 report by the U.S. Army Corps of Engineers estimated that 18 percent of U.S. commerce relied upon the Ohio River navigation system. That same report noted that each day, 192 barges loaded with goods passed by Cincinnati on their way to major ports. An equivalent volume of goods would require 11,520 twenty-five-ton trucks to transport it.

Resources

Publications

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Audiovisual Programs

The Ohio River—Background for Social Studies. 1967. Coronet. Surveys the development of America's busiest inland waterway and the cities along its banks from colonial times to the present (11 minutes). Reserve film through the Cincinnati Public Library. Call 513-369-6900 for borrowing procedures. Junior high to adult.

Maps

U.S. Army Corps of Engineers
Ohio River Division
Federal Office Building
P.O. Box 1159
Cincinnati, OH 45201

Community Resources

The Kentucky Folklife Program
CPO Box 760
Berea College
Berea, KY 40404
606-986-9341, ext. 5139

Figure IVB-1. Ohio River historic Indian sites, 1650 - 1750.

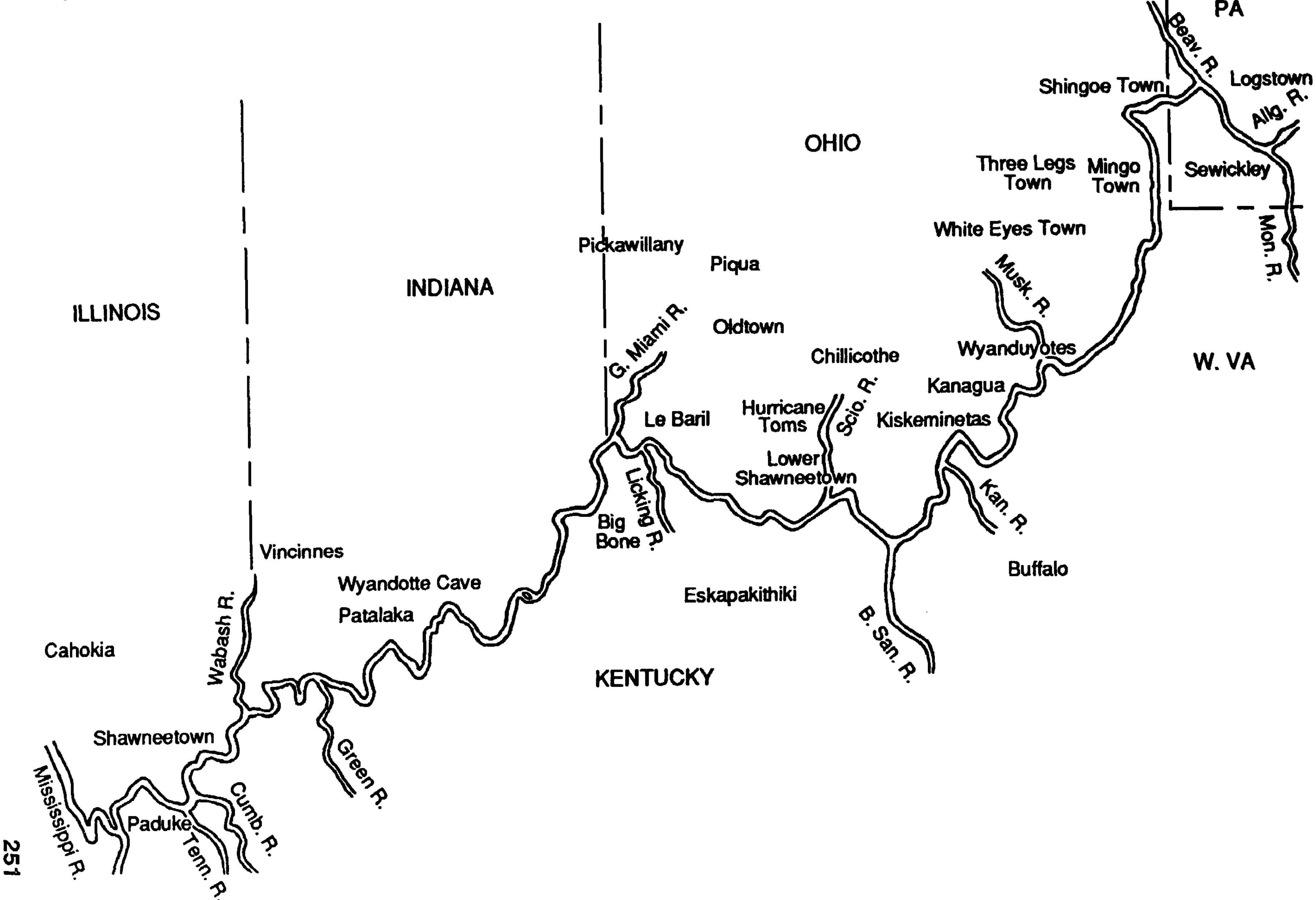
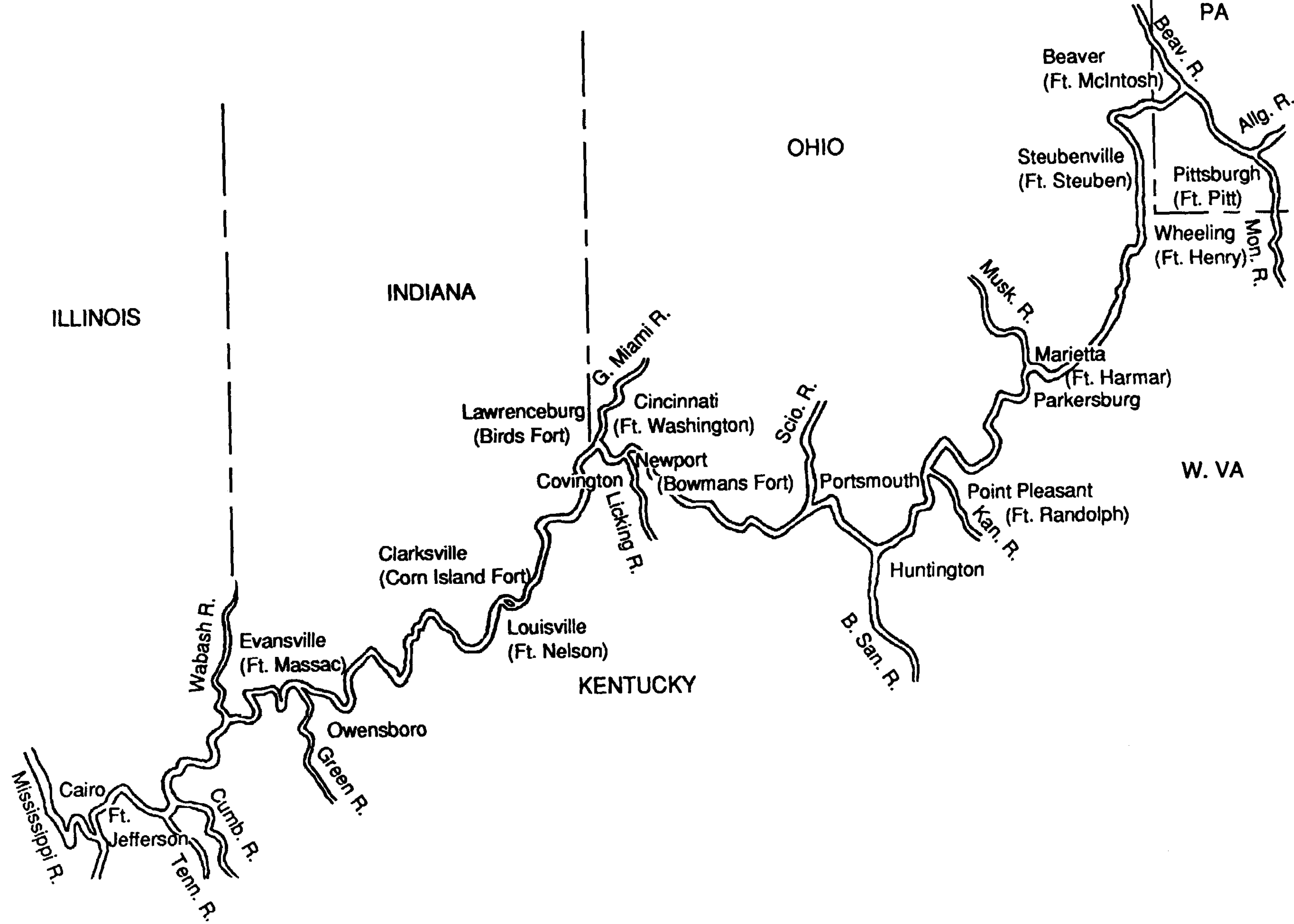


Figure IVB-2. Ohio River pioneer settlements, 1750 - 1810.



B

Activity

Ohio River Place Names

Objective

Students will be able to identify some of the flora, fauna, and minerals indigenous to the Ohio River Valley at the time of European settlement. Students will also develop an understanding of the environment and lives of the early settlers.

Setting

Classroom

Duration

1 hour

Subject

Language Arts, Science, Social Studies

Skills

Classification, Listing, Writing, Description, Discussion, Generalization, Invention, Observation

Grade Level

3-5

Vocabulary

none

Background Information

Refer to Unit IV, Sections B-2 through B-4.

Materials

- U.S. Army Corps of Engineers navigation maps. (See Resources to Unit IV, Section B.)
- U.S. Geological Survey maps.
- Ohio River Valley Place Names map.

Procedure

Part 1

1. Explain that before the Europeans arrived, Indians had their own names for the Ohio River and the surrounding area. The word "Ohio," for example, is an Indian word that perhaps means "beautiful" or "white cap." When Europeans came they kept some Indian names, but also renamed many features of their environment in their own language, English.
2. Point out that the settlers often gave names that described the flora and fauna they saw when they arrived.
3. Show the class examples of the U.S. Geological Survey quadrangle maps of the Ohio River, or U.S. Army Corps of Engineers maps of the Ohio River area. Have students point out some of these descriptive names.

Procedure

(continued)

4. Using the maps listed under materials, and/or the handout of Ohio River Valley Place Names, have students list the names according to the following categories: Plants, Animals, and Minerals.
5. Using the lists students develop, discuss what the environment of the early settlers must have looked, felt, and smelled like.

Note: For younger children, as an alternative to Steps 3 through 5, select certain place names from the map and say them aloud to students. Then conduct the discussion in Step 5.

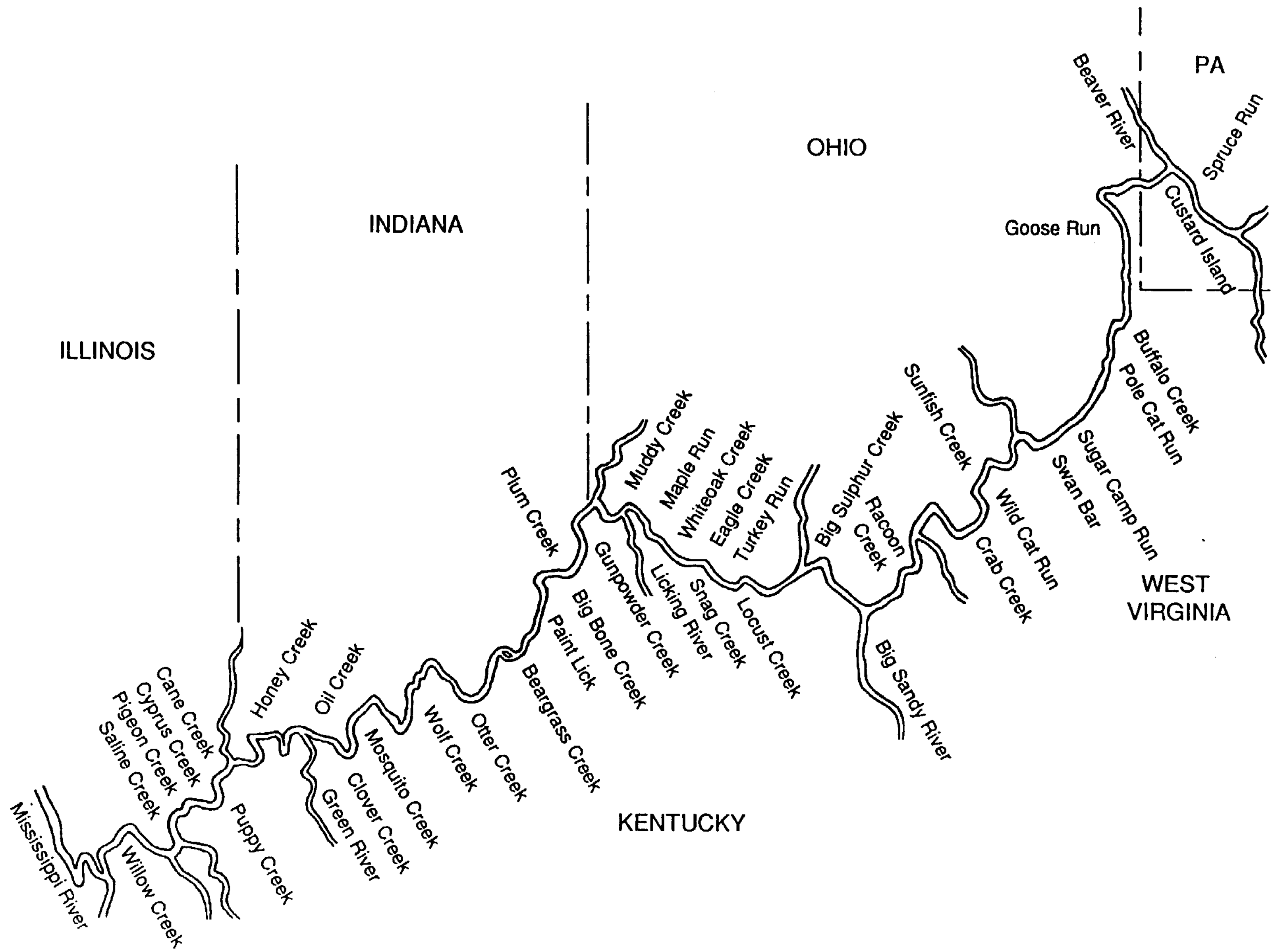
Part 2

1. Using the same maps used above, point out to the class some unusual Ohio River place names, such as: Monkey's Eyebrow, Lost Creek, Rabbit Hash, Rising Sun, Scuffletown Bar, Cold Friday Hollow, Hurricane Hollow, and Haunted House Bar.
2. Have each student pick a place name and write a story about how the place got its name. Encourage students to be creative and use their imaginations.

Extension/ Evaluation

Have students visit a section of the Ohio River or one of its tributaries. Students should identify plants and animals they see. Have students think of their own names for this section of the river. Students might want to write in the new names on a geological map of the area.

Ohio River Valley Place Names



B

Activity

The Shape of Our Town

Objective

Students will be able to describe the physical geography of their town and its influence on the development of their community.

Setting

Classroom

Duration

One 1-hour period

Subject

Social Studies

Skills

Map Reading, Analysis, Inference, Visualization, Description, Discussion, Drawing, Observation, Generalization

Grade Level

4-6

Vocabulary

geographical

Background Information

Refer to Unit IV, Sections B-2 through B-4.

Materials

- U.S. Geological Survey maps of the local area.
- Crayons or markers, and colored pencils.

Procedure

1. Discuss with students the concept of how geographical features such as rivers, swamps, and farmland could affect the way an area was developed by the European settlers.
2. Pass out geological maps showing the community students live in.
3. On tracing paper or clear plastic, have students draw over the map and show the buildings, bridges, neighborhoods, and other features that make up their town.
4. Have students look at the human-made features in relationship to the geographical features. Discuss how geography influenced the development of their town.

Extension/ Evaluation

Have students take a tour of their community's downtown area with someone from the local historical society, who can explain the significance of what students see. If a tour isn't possible, invite someone from the historical society, or a knowledgeable person, to speak to the class about the history of their town. The talk should emphasize the role played by geography. (You might want to refer to Appendix C, "Guidelines for Interviewing People.")

Have students use their local library to do additional research about the history of their community. Students might choose specific industries or companies and write a history of their development. They could also look at the successive development of various neighborhoods within their community. The reports should focus on why development happened as it did.

B

Activity

Examining Local Economies of Current Ohio River Communities

Objective

Students will learn to appreciate the relationship between natural resources and economic development by examining the local economies of Ohio River Valley communities.

Setting

Classroom and library

Duration

A minimum of two 40-minute periods and library research time

Subject

Economics, History, Social Studies

Skills

Analysis, Description, Discussion, Inference, Listening, Research, Reading, Writing, Public Speaking

Grade Level

6-10

Vocabulary

economies resources

Background Information

Refer to Unit IV, Sections B-3 through B-4.

Materials

- Local Economies of Current Ohio River Communities map.
- Library books.

Procedure

1. Pass out the map, Local Economies of Current Ohio River Communities, that shows unique economies that developed along the Ohio River.
2. Discuss how these developments might have taken place, and their relationship to the natural resources of the region.
3. Have each student pick one Ohio River city or town and then research the unique economic product or service of that city or town. Have students explain why that product or service might have developed there.
4. Have each student present their findings to the class in a written or oral report.

Extension/ Evaluation

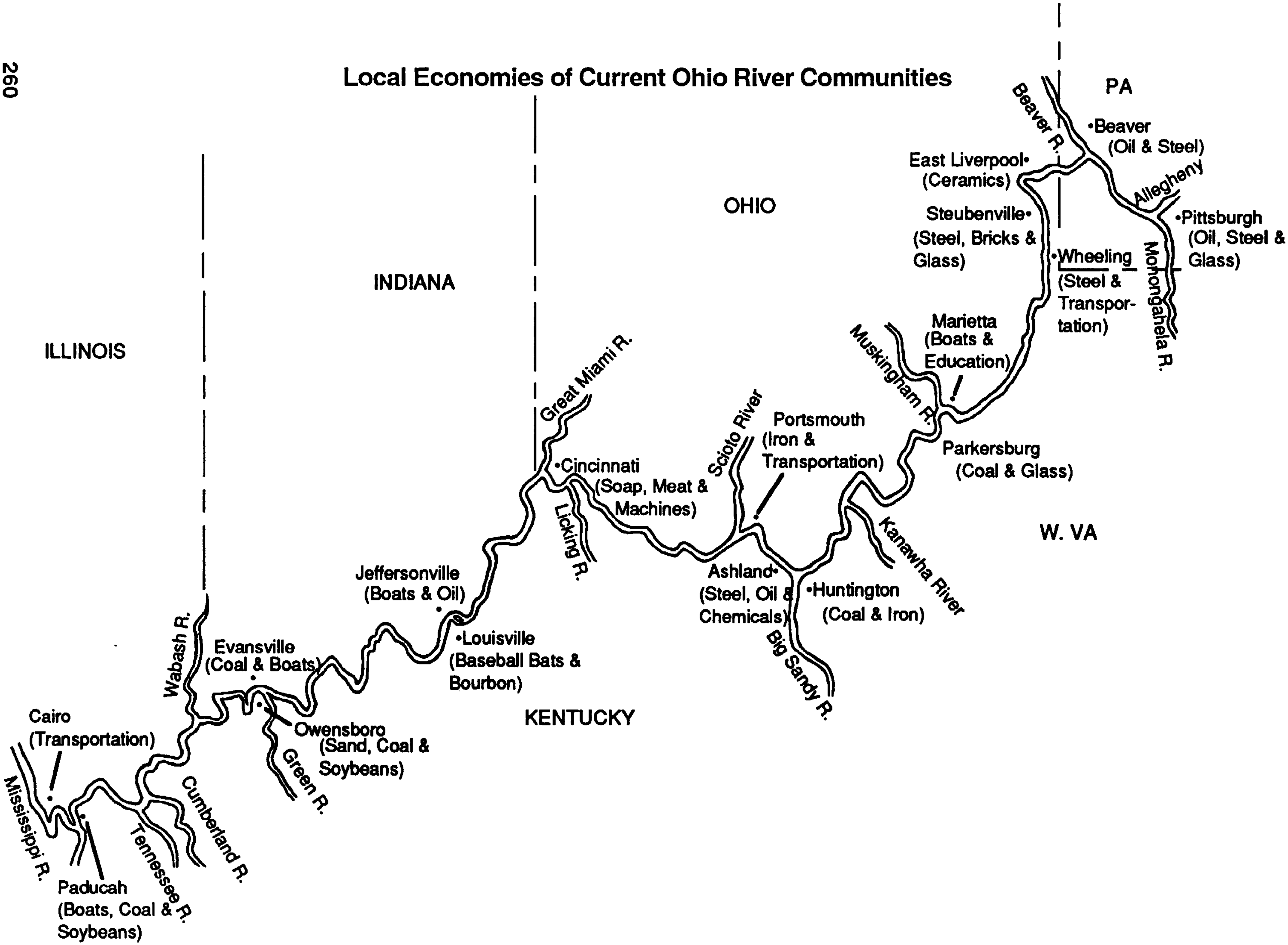
Visit a local business or industry.

If available, visit a local museum that has an exhibit showing the development of a local economy.

Invite some local business people to talk to students about why they located their business in this community. Ask students:

- Are these the same reasons that earlier business people had?
- If not, how are they different? Why?

Local Economies of Current Ohio River Communities



B

Activity

Tales of the River

Objective

Through books and first-person accounts, students will learn about the everyday lives of people who lived along the Ohio River. By identifying with these accounts, students will develop an appreciation of the beauty and influence of the Ohio River on American culture.

Setting

Classroom and home or library for outside reading

Duration

A month for reading the books and sufficient class time to allow each student to report orally

Subject

English, History, Music, Social Studies

Skills

Reading, Reporting, Writing, Description, Analysis, Discussion, Public Speaking, Generalization, Visualization, Comparing Similarities and Differences

Grade Level

K-12

Vocabulary

none

Background Information

Refer to Unit IV, Sections B-1 through B-4.

Materials

- Library books.
- First-person accounts of life along the Ohio River. Some possibilities are *New Burlington* by J. Baskin (New York, NY: Norton Press, 1976); *Payne Hollow* by H. Hubbard (New York, NY: Eakins, 1974); and *Above the River* by J. Wright (Middletown, CT: University Press of New England, 1990).

Procedure

1. Discuss with students the value of reading personal accounts of life in other times. Explain how seeing directly through someone's eyes gives you more details about an environment and helps you understand the emotions people felt.
2. Bring in examples of books written by Ohio River authors. Discuss the various authors, their books, and what they tried to accomplish in their writing. In addition to books, you may want to include literary journals or history books containing first-person accounts of life in the Ohio River Valley.

Procedure *(continued)*

3. Have each student choose a book to read. If students prefer to read literary journals or first-person accounts, have them read several. Students should read the books at home.
4. Have each student write a book report and/or report orally to the class. In their reports, students should describe at least one feature of life in the Ohio River Valley that their book/accounts helped them appreciate better. Discuss the reports with the entire class. Have students compare life along the river in earlier days with their own lives.

Note: For younger children, as an alternative to Steps 3 and 4, read stories or excerpts from accounts aloud to students and discuss. You may also wish to introduce students to songs that have been written about the Ohio River or other rivers. (Some examples are *Ohio River, She's So Deep and Wide; Beautiful Ohio; Waiting for the Robert E. Lee; Cruising Down the River on a Sunday Afternoon.*)

Extension/ Evaluation

Have students choose a type of person who lived in the Ohio River Valley during the time of early European settlement. Suggest some possibilities: an Indian who was losing his or her land, a keelboat crew member who carried early settlers, or a woman who worked on her family farm. Have students write a fictional diary entry for a week in the life of that person.

Have students research other ways in which the historical people of the Ohio River Valley expressed themselves, e.g., through songs, dances, games. Students should report to the class or prepare an exhibit for the school.

Have students identify long-living citizens of their community who lived along the river when it was different. Have students interview them about their lives and changing community. Students should tape record or videotape the interviews. After sharing these interviews with classmates, students may want to make the tapes available to their local library. You may want to refer to Appendix C, "Guidelines for Interviewing People," at the back of this curriculum.

B

Activity

Watered Down History

Objective

Students will be able to: 1) describe the geographical formations and natural resources along a particular section of the Ohio River or one of its tributaries; 2) describe the development of that same area through various periods in history; 3) analyze cause and effect relationships between the geography of the region and its development and history; and 4) predict the future of this portion of the river.

Setting

Classroom and library; a visit to the area is recommended

Duration

A minimum of three 45-minute periods

Subject

Geography, History, Economics

Skills

Analysis, Classification, Communication, Comparing Similarities and Differences, Description, Discussion, Inference, Interpretation, Interviewing, Invention, Listening, Listing, Mapping, Prediction, Public Speaking, Reading, Reporting, Research, Small Group Work, Synthesis

Grade Level

7-10

Vocabulary

none

Background Information

Refer to Unit IV, Sections B-2 through B-4.

Materials

- Library books or other reference sources.

Procedure

1. Explain the general purpose of the lesson, which is to understand the relationship between the geography and resources of an area along the river and how it developed throughout history. The principles learned should help to predict the future of the area.
2. Ask the students to refer to a county, state, or regional map and—as a group—select one portion of the Ohio River, or one of its tributaries, that will be the focus of their research. Point out that it might be easiest for students to select their own or a nearby community, since this will allow greater access to historical information.

Procedure *(continued)*

3. Once their choice has been made, divide the class into small groups. Ask students in each of the groups to choose a major topic area, e.g., geography and resources, early settlements, early industries, recent history. Choosing a variety of topics helps establish historical perspective and spreads out the demand for reference sources. Within the general topic areas, students might explore specific areas such as pollution and misuse of the river, life and culture of the European settlers who "discovered" the area, 19th and early 20th century immigrants to the area, recreational uses of the river, etc.

4. Ask students to identify resources for their research. If possible, try to include living reference sources such as long-living citizens, members of local historical societies, and history and social studies teachers from high schools or colleges. Old newspapers and historical archives may also be available. Students might ask the following types of questions.

   - How did European explorers find this place?
   - What was the geography of the area like when early settlers came here? What were the local natural resources?
   - What was life like for the early European settlers?
   - What immigrant groups came to this area? When did they come? Why?
   - What industries developed in this area? Why?
   - What is this area like today? How has it changed?

Note: You might like to refer to Appendix C, "Guidelines for Interviewing People," at the back of this curriculum.

5. Have the teams plan to report in an historical sequence from the earliest times to the present. Hold a class meeting to identify the major time periods each group is researching. Establish a sequence for reporting so that each topic—industries, lifestyles, immigrants—can be addressed in each major time period.

6. When enough information is gathered, have students begin reporting. You might want to have students create displays of information for each major time period.

7. When students have finished reporting, ask them collectively to analyze major changes that have taken place throughout this area. Include the role of the river or waterway in this analysis. Have students create a timeline noting major events in the region's history.

Procedure *(continued)*

8. Based on what they have learned from the past, have the students create a "history" of the future of this area. Alternatively, students might want to predict a utopian future—an image of the future that they feel would represent an effective ecological balance among people, the environment, and the river. Ask students:

   - Does this image differ from what you think will actually happen to this region? If so, why?
   - Are there actions you could take to change the future of the region?

Extension/ Evaluation

Have students compile a "biography" of their region to summarize this activity.

Have students write a play with traditional or original music to portray the history of this area. End with possible futures being depicted—emphasizing human responsibilities for the consequences of our choices.

Have students report their findings to the community they have chosen. This might take the form of a museum exhibit, or addressing community or historical groups. Students should be sure to include their analyses of the future.

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